# Self-determined Teacher Learning in a Digital Context:

# Fundamental Change in Thinking and Practice

**Deirdre Butler**

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy, Joint Faculty of Education, St. Patrick's College, Dublin City University.

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30th June 2004

# Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

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Date: 30th June 2004

## Acknowledgements

I am indebted to the teachers and children within the EM community. Their commitment and dedication have created a vibrant, open, trusting space within which we are all learning about learning together.

Generous funding from Ireland's National Centre for Technology in Education and the Higher Education Authority made the work possible.

The staff at St. Patrick's College, in particular the Digital Learning team (Denis Twomey, Margaret Leahy, Karin Duffner and John Smith) have been a great source of support and encouragement. I was able to engage wholeheartedly with the research as the team were keeping everything running smoothly on a day-to-day basis with the graduate and postgraduate coursework and development. Special thanks are due to Denis and Margaret for the countless ways they helped, particularly in the final stages of document preparation and the Viva process.

I would like to thank my internal supervisor, Hugh Gash for his advice and support. Since I came to St. Patrick's College in 1998 as a member of the Education department, Hugh supported me in the development of college structures that express my ideas about optimal uses and conditions for use of technologies in education. I have no doubt that his continued encouragement will help in carrying forward the results presented here.

When I read Seymour Papert's book in the early 1980's I could never in my wildest dreams have imagined that one day I would have the privilege that this world-renowned man would become my doctoral advisor. It has been a wonderful experience to have many long conversations with Seymour, who has an amazing ability to frame a question so that you are able to think more deeply and with an entirely different perspective. Seymour's warm, optimistic, expectant, and above all playful, engaging approach to life and learning has inspired me to complete this work and continue to explore what being digital in learning can be and how each person can reach their full human potential.

Fred Martin's enthusiastic, creative and congenial personality, and his willing co-operation from our first meeting in October 1998, made possible some important realisations of ideas I had been germinating for many years, which eventually led to the development of the EM community. It was a wonderful honour to work with this member of the original team who designed and developed the computational materials that became central to the EM effort. Our workshops and classroom sessions benefited enormously from his expertise and insights. I am grateful also for his framing of the larger issues that our efforts address. He challenged me to consider the importance of the work and fortified me as I employed it in questioning existing school practices. I look forward to our continued efforts in creating new possibilities for teachers and children.

From my first meeting with Glorianna Davenport she believed in my ideas and supported me by whatever means she could. Her generosity knows no bounds as demonstrated in so many ways over the years. It has been a privilege and honour to work with such a committed, resourceful and dedicated person, who not only "talks the talk" but also "walks the walk".

Many long conversations with Carol Strohecker over the past three years have helped me examine carefully and question critically the ideas expressed in this work. On my bad days and when things got especially tough towards the end she was always to hand gently encouraging me to continue writing. Despite being tremendously busy herself she always found time to discuss, critique, question my ideas or simply lend a sympathetic ear. The phrase "bird by bird" became her mantra that helped focus me and keep me on track.

The greatest influence on my development came from my Mam and Dad (Marie and George Butler) who sowed the seeds of curiosity and confidence in me to push out the boundaries in whatever I did. Sadly my Dad passed away suddenly just a few weeks before this work was completed but he'd have been proud, as he believed in seeing things through to the end no matter what obstacle may be put in the way to test you. Not one to blow his own trumpet, he was a dedicated, caring, tenacious, independent thinker who was a wonderful role model for me growing up. I dedicate this work to his memory.

Although mentioned last in these acknowledgements, this is not the place these two special people occupy in reality, as they are the most important people in my life: my husband, Andy, and our son, Dónal. They have been my steadfast rock and pillars of strength throughout the conception and development of this work. Without their unflinching faith and belief in me, coupled with their constant encouragement and support, particularly, towards the end, this work would never have been completed. Andy, especially, who shies away from the limelight himself, is indeed "the wind beneath my wings."

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# Abstract

"Self-determined Teacher Learning in a Digital Context" reports on a longitudinal study of teacher empowerment through Constructionist learning about computational technologies and learning about *learning* itself.

The study includes but looks beyond how teachers engage with technology, to how they redefine their own understandings of learning as they use technology in working alongside their students. The teachers' emerging self-reflective practice enables them to better understand the multifaceted structure of the learning situation and their own relations to its social, cognitive, and affective aspects. The "Empowering Minds" study also addresses how teachers can become critical judges of technologies, in order to define for themselves and suggest for others what being digital can mean in learning.

These processes have the potential to change educational strategies on personal, community and national scales. How teachers understand learning and how we conceptualise teacher learning will directly affect future generations' potentials.

Teachers grapple with epistemological issues in designing and developing environments around new protean materials that enable each person's construction of ideas and expression of self. Learning theory becomes less abstract and more meaningful as teachers create a language for talking among themselves about learning. The resulting concretisation of learning processes becomes possible through anchoring the learning with and about technologies in the teachers' everyday reality of the classroom.

Teachers become empowered to use their own practice as "an object-to-think-with" in the Papertian sense. By externalising and examining their understandings of learning, they experiment with and ultimately transform their teaching practice, their relationships with their students, and their understandings of their role as teachers.

Constructionists have been challenged to demonstrate that their assertions about education work. The approach described here is a compelling response. Furthermore its continuance among the original participants and its extension to a variety of new initiatives demonstrate both sustainability and scalability.

# Preface
# Personal Context

"Nothing of real worth ever happens by chance."

--Brother O'Sullivan (1985)
Professor of Education,
NUI Maynooth, Ireland

Through this brief synopsis of my background and professional evolution I hope to illuminate my interest in teacher learning, and to explain the ideas and personal perspectives I bring to my research, of which this dissertation is but one part. I hope these next few pages will bring you to understand the influences and inspirations that have guided my work.

## A Vision: What Learning Could Be

Before spending a year (September 1997—September 1998) as a research fellow in the School of Computer Application at Dublin City University (DCU), I taught for 17 years at all primary school levels, with children four to 12 years of age. During that time, I was a regular class teacher, a resource teacher for the travelling community, and a deputy school principal.

I first got interested in using digital technologies in primary school in the early 80s, when I began my teaching career. I became interested in mathematics education and worked with Sean Close at St. Patrick's College, where I had done my undergraduate work. His colleague, Fred Klotz, was interested in using the Logo programming language; thus began my long-term connection with the ideas and work of Seymour Papert and the work of the Epistemology and Learning group at Media Lab, Massachusetts Institute Of Technology (MIT).

Together, Sean, Fred and I, began weekend workshops and summer camps for mathematically talented children, using Logo as the vehicle for exploring ideas and developing projects. I worked with these children for many years and in 1988, completed my Master's Dissertation, which investigated the problem-solving strategies children used when programming in Logo. At the same time, I was trying to pursue these important ideas about problem-solving daily in my classroom, but this was proving exceedingly difficult.

The problem was access to computers. There was no designated funding for such activities from central government, which provides the majority of the funding for the Irish school system. Strangely, we could get a grant towards the purchase of a computer trolley, as it would be funded as school furniture. But we could not get money for a computer to put *on* the trolley. Consequently, prior to the establishment of the National Centre for Technology in Education (NCTE), in November 1997 and the announcement of IT2000 any computer equipment we purchased came primarily from the school's own fundraising initiatives. And equipment was expensive, so only the very committed and dedicated could fight to justify the expense to the school finance committee, the principal, and the other teachers when so many other priorities were also demanding attention, such as library resources, mathematics materials, physical education and art equipment and so on. Luckily, I had an enlightened principal, Peadar O'Sullivan, who encouraged the use of technology despite the fact that he never used it himself. But he felt my enthusiasm and the engagement of the children in the projects they pursued was justification enough. During the next decade, as the technology developed, the children and I experimented with many different ideas, materials and technologies. Obtaining resources always presented difficulties that were compounded by the lack of official validation which Department of Education and Science funding allocations would have provided. So my pursuit was often arduous and solitary.

During these years, I was also deeply involved in mathematics education programmes for practising teachers and was working part-time with pre-service teachers in St. Patrick's College, Dublin. In the course of my work with mathematics inservice programmes, I tried out a variety of strategies with teachers: the one-off, stand-alone workshop; series of workshops over a number of evenings or weekends; and the five-day summer course. Gradually, as I watched hundreds of teachers work through these programmes, I had two disconcerting realisations: they had a wide range of learning styles, but they generally did not seem to reflect on how they themselves learned.

Many of the teachers I worked with seemed to see no connection or relationship between how they learned themselves and how they taught their students; rather, they were inclined to view teaching and learning as two entirely distinct, unconnected activities. Generally, they thought concrete materials were useful only for children at the very junior end of school, to use in building their understanding of concepts. Some teachers seemed to think that learning was confined to the search for solely correct answers along solely correct paths of inquiry. So, naturally enough, they were interested in "quick fixes" or "handy tip" approaches. It didn't occur to them to identify or engage with the questions of how people learn and who defines what should be learned. Nor did they seek or recognise interdisciplinary implications—for instance, that good learning strategies and approaches in maths, such as simplifying a problem, could also apply usefully to other learning situations.

I also began to get uncomfortable with the idea that, for the most part, I was deciding on the content for these teacher workshops, as I was considered the "expert." And I was troubled because these teachers had no sustained support for implementing in their classrooms the ideas they had been working on within the workshops. Also, as the teachers were coming to Education Centres or other outside venues for the workshops, I had no real grasp of their widely differing daily working contexts. In the early to mid-90s, the "whole-school approach" to planning was becoming popular, so I suggested to my local Education Centre, of which I had been an active executive committee member for many years, that I work with teachers on a whole-school basis in mathematics.

I worked with many schools and found the work rewarding. However, I soon realised I couldn't do this work part-time, while working fulltime as a teacher myself, and provide the type of support that was needed to instigate real change. Many of these teachers expressed a deep desire for me to be able to work alongside them with their children, to experience for themselves what this type of learning really could be.

Life was extremely busy as I pursued my quest to understand how learning in school was constituted, and how it could look so different, depending upon context and the teacher's own perspective and understanding of learning. I realised that I wanted to pursue this burning interest full-time, so I began seriously to contemplate the idea of full-time research, bringing together my interests in learning, teacher development and digital technologies.

Around this time, in the mid-90's, interest began to blossom with regard to integrating digital technologies into the school system, and some funding was becoming available for research in this area. After investigating various options to pursue my research interests, I was awarded a research fellowship for three years in the School of Computer Applications at Dublin City University (DCU), to work with a community-based technology centre in a rural setting. The teachers and children in the surrounding schools also had regular access to the centre. In addition, I would also work towards a PhD. This seemed to be what I was looking for, but while in the School of Computer Applications, I was quickly exposed to the world of hard-edged computer science, and I realised that the people working in it had little or no idea that anyone might possibly not be interested in technology. Nor had they any deep understandings of the complexities of classroom life, teacher development, or the fact that people take a long time to adjust to change.

For example, while at DCU, I worked with the Centre for Teaching Computing (CTC), which was engaged in a project called Tech Corp that provided recycled machines from industry to be used in computer labs in schools. Some of the personnel on this project could not comprehend why, when the schools got the equipment, the teachers "just didn't use it" or that they were having such "simple" technical problems with their networks. The schools, however, had not been given a choice in how to deploy the donated computers: the lab scenario where all the machines were networked in one room was foisted upon them. At the time, though the schools were eager to accept the donated equipment, they never questioned the wisdom of having the equipment centralised in a lab that was going to need ongoing technical support. The teacher development that was offered was also very much skills-based, with a one-size-fits-all approach.

Many long and heated discussions and debates with faculty about these issues helped me to crystallise my ideas about the complex relationships among digital technologies, teacher development and classroom realities. I developed these ideas further when I worked with teachers on the Master's programme (MSc., Computer Applications for Education) at DCU. My suspicions about the appropriateness of the course content were confirmed and I realised that the teachers generally felt unable to relate to a lot of the course content, as they saw no connection between it and their reality in the classroom. The faculty responsible for the design of the programme told me they saw themselves as providing the "technical aspects of the technology" and that the teachers somehow would have the "teaching and learning bits" and could fill in what they needed. It was clear to me that such an approach was fraught with difficulties because course work scarcely could be motivating unless it addressed the context in which it was to be anchored. Without support, teachers scarcely could be expected to make the connections between their everyday realities, their own conceptions of learning and the technology. I defined the questions I wanted to begin investigating and understanding better:

- What do teachers need in order to engage with these digital technologies in meaningful ways ?

- Was there a link between teachers' understanding of learning and their views of technology?

The prevalent uses of technology bolstered either pure skills development (for example, the European Computer Driving Licence mania) or the existing curriculum (drill-and-kill software, or using word processors to reproduce text). I was becoming more convinced that these approaches could not kick-start a major rethinking of ways digital tools could be used in the classroom. Nor could they radically change the future of classroom learning. I trawled extensively for other researchers' work around the world, and what I could learn from their efforts. I also decided that I needed to change direction and work within an educational context rather than the School of Computer Applications, so I applied for a teaching position to develop the profile of digital technologies within the Education Department at St. Patrick's College.

Another "critical event" (Woods, 1993) helped to determine the scope of the research opportunity that became the focus of this study: the announcement of imminent School Integration Project (SIP) funding from the NCTE for innovative and creative projects in schools. At long last, there was going to be money! Not only to purchase hardware and software, but also—and more importantly—to actively encourage and fund innovative initiatives for uses of digital technologies. This was manna from heaven.

From my reading, I had deduced that I might get teachers focused on learning rather than merely on the technology, by moving out of the exclusive keyboard-and-monitor environment and into some space that was very new and different to everyone but which offered limitless scope for development. I was intrigued by the Programmable Brick technology developed by members of the E&L group (Fred Martin, Randy Sargeant and Brian Silverman), and felt it would be exciting for teachers and children to work with. It could move people's fixations away from the computer and enable them to develop and build things in new and exciting ways. It had the power to shift the locus of control from the machine to the hands of the learner, who no longer would be seated in front of the computer, effectively being programmed by it. With this Brick in their hands, they would be free to design, build and programme whatever they wanted. Combined with an expressive set of materials (sensors, motors, LEGO building pieces and craft materials), this Brick could open up a new world of exploration and learning for children. It would no longer be possible to justify the practice of parking solo children at machines, thereby perpetuating the transmission mode of passive learning. This all-to-common approach really only pays lip service to using digital technologies making no real attempt to question what these technologies can offer or how classroom practices could change with their use. I believed the new Programmable Brick technology could present very different possibilities. The big question then became how I could learn more about this technology and get teachers interested in using it in classrooms. My main challenges were finding out more about the Programmable Brick, making contact with the E&L group, and securing funding to bring this technology to classrooms.

From web searches, I had learned that Fred Martin had worked in elementary schools in Rhode Island while developing the Brick technology. I thought he would be the person to talk with, as not only had he developed the technology, but he also had experience working with teachers and children. He could share with us very practical advice about how we might introduce this technology into classrooms. Serendipitously, at that moment, Fred was in Sweden to host a workshop using the Brick technology, and he was scheduled to lecture at the DCU School of Engineering.

While engaged in my detective work to make contact with Fred, I had also been finding out as much as possible about the impending funding for the NCTE's SIP initiative. I discovered that proposals would have to be submitted directly by the schools, as SIP was framed as a grassroots initiative. So I began to talk with the primary school where I still was officially deputy principal though I was at this time (1998) on career break from primary school teaching. Eamon Scully, the new principal, agreed to put forward a proposal for the SIP initiative although he himself had no real interest in technology. He felt, though, that a new staff member who was very interested in technology, Stephen Mc Carron, would be really taken with the idea. And he was. We talked at length about my ideas, and he read up on the information I downloaded for him. He was excited when we met again and was able to come along with me to hear Fred Martin talk at DCU that October. Also with us was my good friend, Michael Hallissy, who had just begun working with the NCTE and who now, years later is playing a critical role in a significant development of the ideas presented here.

Stephen and Michael were excited by Fred's presentation and agreed to help put the proposal together if I could get Fred involved. Taking my courage in my hands, I approached Fred. He generously agreed to meet with me to discuss the possibilities of working with us. We continued discussions by e-mail, and together we developed a proposal for the SIP initiative, which—after much negotiation and convincing—was funded for a year.

And so began the Empowering Minds project. I knew a year's funding was not going to be enough to effect any significant shift in beliefs or understandings, but it was a start. And we had been promised a review with the possibility of continued funding.

Another event that was to prove critical occurred during that first year when I met with Glorianna Davenport and Seymour Papert (December 1998) while they were in Ireland on an exploratory visit prior to the establishment of Media Lab Europe, which was to be the European research partner of the MIT Media Lab situated in Dublin. We began a relationship that later was instrumental in securing future funding for the project through the Higher Education Education's (HEA) Multimedia Research Fund (MMR) established in 2000 to encourage collaboration between the newly-founded MLE and other Irish third-level institutions.

I sketch this story in order to highlight the fact that nothing big happens by accident. Preparation, planning and hard work all have to occur ahead of time, especially if the big thing is new, and it poses the prospect of changing the accepted world view or status quo. Someone has to do a lot of groundwork and feel passionate enough to move things forward in spite of opposition. The words of Professor of Education, Brother O'Sullivan, during my master's programme in the mid-80s now held real meaning for me. He always said that nothing of real worth happened by chance, and he often talked about the parable of the mustard seed that wouldn't grow unless it fell on prepared ground. He always placed great emphasis on the importance of serendipity and the prepared mind. Now, from the plateau of experience, I could look out and see the vast untilled fields of unlimited potential as we began our explorative journey.

But no one person can do such big things alone; they must join forces with others who can help work towards a common goal. Building a community to cultivate and grow the ideas is imperative for any sustained development. So, thanks to Brother O'Sullivan, I had internalised these precepts and appreciated them as all members of our group worked together to build this new learning community within the Empowering Minds project.

The Irish are renowned as great story-tellers, which may have influenced the choice of theme (Story, Myth and Legend) that the teachers chose to explore using these new computational materials. Glorianna Davenport, who provided enormous support and encouragement for me personally as well as for the teachers, was interested in story and ways in which different media, particularly film, could be used to tell stories. I wanted to tell the story of how teachers learn, and the teachers wanted to capture the story of the learning processes their students were engaged in. Fred Martin was interested in developing technologies to enable people to build and discover new ways of learning and appropriate these new technologies to think about their own learning. A constant exchange of cultures and worldviews contributed to the richness of the experiences for all involved in the project. For me particularly, this immersion into a culture of stimulating ideas continued over the next five years, thanks to my work as a student of Seymour Papert, and my continuing relationships with Glorianna Davenport (MIT/MLE) and Carol Strohecker (MLE). During this time, at MLE and MIT's Media Lab, I met and talked with people from a host of different backgrounds, from all over the world. And I travelled:

- to work with teachers in Costa Rica (Jan 2001) with David Cavallo's "Future of Learning" group
- to Mexico, to act as a facilitator at the first Learning Hubs Summer Institute (July 2001), where I worked with teachers from all over Central and South America as well as researchers from many different institutions
- to Maine, USA to see some of the projects Seymour Papert was working with (Juvenile Detention Institute, the school-within-a-school) and to meet with some of the personnel from the Learning Barn as well as a group of teacher educators from Denmark.

Spending time outside of my own culture was valuable not only personally, but also as a strong professional influence, as I was exposed to different ideologies and perspectives that profoundly challenged my own deep-rooted assumptions and ideas, and made me reflect upon their validity. After our face-to-face meetings and discussions, I could not have maintained my relationships with all the people I have met without the communication made possible by digital technologies.

Another strength that I believe helped in the establishment and development of the Empowering Minds project is my firm belief in the art of the possible: I believe we can always find a way around any obstacle that may be thrown in our paths; if we just look hard enough and dig deeply, something will develop. From the beginning, this conviction was indispensable in helping me think around corners, especially in convincing the NCTE in the initial stages to take a chance and fund the EM project. The helped me through many difficult times, too, such as finding funding to continue the work of the project, and installing the wireless hardware in all the schools.

I also wholeheartedly believe in real investment and trust in people because what we invest in the beginning comes back a hundredfold if people have enough time to explore and develop their own perspectives. This faith strengthened my resolve to insist on starting with a small group of teachers and developing slowly in spite of early pressure to expand.

I hope this background sketch of my personal context gives you a sense of the backdrop against which I initiated the Empowering Minds project. I intend it to explain and illuminate my role and the experiences that informed my understandings of the relationships I now see—and feel so deeply about—among teachers, learning and digital technologies.

# Chapter One
# TEACHERS LEARNING ABOUT LEARNING?

This is a longitudinal study of teacher empowerment through Constructionist learning about cybernetic technologies and learning about learning. It looks beyond how teachers engage with technology, to how teachers' use of technology as they work alongside their students allows them to redefine their own understandings of learning. As a result, they engage with their personal epistemologies and are challenged to change their ways of working with children in the classroom. Focusing on the multifaceted structure of the learning situation (social, cognitive, affective), this study demonstrates what is necessary to support teachers in becoming self-determined learners. In addition, it addresses the question of how teachers are empowered to become critical judges of digital technologies, in order to determine what being digital can mean for learning. This study has the potential to change educational strategies on personal, community and national scales.

The Empowering Minds (EM, http://empoweringminds.mle.ie) project, which provides the primary material for this study, was initiated by the author in October 1998 and is a joint collaboration between St. Patrick's College (www.spd.dcu.ie ), Media Lab Europe (MLE, www.medialabeurope.org ), the National Centre for Technology in Education (NCTE, www.ncte.ie) and the MIT Media Lab (www.media.mit.edu). The nine teachers from four schools selected for the first phase of the EM project[1] (March 1999 to June 2000) are loosely representative of the main school-types prevailing in Ireland (large middle-class suburban; inner-city disadvantaged; medium semi-rural; two-teacher rural). Targeted expansion for the second year (August 2000 to June 2001) included more small rural schools and disadvantaged schools, as well as some single-sex schools and children with special needs. At present in the EM project, there are 29 teachers from 13 schools with a wide geographical spread across Ireland. All the teachers volunteered for the project, and their experience level using digital technologies ranges from complete beginner to experienced user. A balance of male and

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[1] Funding for the first phase of the EM project (March 1999 – June 2000) was provided by the NCTE's Schools Integration Project (SIP) initiative (www.sip.ie) and *eircom*, (the privatised Irish telecommunications company) under a special grants program that specifically encouraged collaborations between Irish schools, universities, and industry. Funding for second year of the project (August 2000 – June 2001) was provided under the NCTE's SIP initiative and the Irish Higher Education Authority's (HEA, www.hea.ie) Multimedia Research Programme (MMRP 2000) fund for collaborative research between Irish Universities and Media Lab Europe. The SIP initiative ceased funding for all projects in August 2001 but the EM project continued to receive funding from under the MMRP initiative from August 2001 until December 2003.

female teachers exists (14 males and 15 females), and they range in age from early twenties to late fifties. Also, they vary in classroom experience from newly qualified teachers to some who are near retirement, across the range of different school contexts.

An important context of this study, which centres on the Empowering Minds Project, lies in the Irish Department of Education and Science (DES) initiative called Schools IT2000 (DES, 1997). The type of teacher professional development programmes put in place by policymakers demonstrates not only how those policymakers understand the functions of digital technologies in the learning process, but also clearly demonstrates what they value as knowledge and the role of the teacher. This work examines those assumptions in the Schools IT2000 initiative with a view to interrogate the model of training it implies, and criticising that model as inadequate as well as outmoded. Alternatively, I propose a model of teacher professional development based on current thinking about learning and a social Constructionist epistemology. This study looks beyond how teachers engage with technology, to how teachers' use of technology as they work alongside their students allows them to revise their understandings of learning itself. Using digital technologies consequently means more than integration within the existing curriculum, and teachers' preparation for using these technologies moves far beyond training. Through learning about their own learning styles and about the phenomenon of learning itself, teachers become empowered to take on far more than today's technologies. They become able to construct learning environments for themselves and others in which ongoing adoption, and indeed innovative generation, of new technologies is possible. Teachers have the potential to contribute both to inspirations for new technologies and to the education of new generations of technology innovators.

For several decades, teacher networks and researchers interested in the professional development of teachers have been examining classroom practice, using what is generally termed, "Action research". However, we must ask how often the underlying philosophy that informs classroom practice is critically questioned and examined. Too often, it is assumed that teachers just need to be better able to talk about and describe their practice, rather than considering the fact that the practice may need radical rethinking. Similar assumptions are made when digital technologies are introduced, as many think that it is just a question of "fit" to integrate the "information and communications technologies" (ICT) successful in the business world into the existing educational system. This assumes that the business system or model is adequate or appropriate to the classroom. Rather than rethink what's in existence, the focus is on integration and teacher training. In contrast, and consistent with Vygotskian thinking, this study claims that changes in tools could result in changes in thinking, and radically alter our view of the world. Using provocative computational materials rather than being restricted to information and communications technologies, we could create a context for questioning existing values and beliefs about learning. This is possible only if these computational materials are not seen simply as tools to fit the existing system, or that the technology in and of itself can make a difference ("technocentric" thinking, Papert, 1990). Furthermore, the overall "systems thinking" engendered by these computational materials and associated cybernetic models are useful in many realms beyond the immediate contexts of teacher development and educational reform. Principles basic to complex dynamic systems – such as feedback, variables and functions – characterise economics, natural ecologies, traffic patterns, families and an endless host of other aspects of life and environment that have other important applications now and in the future.

Thus, we need a different vision of teacher development. The current notion of 'teacher training' does not generally entail personal responsibility, so the teacher not only becomes disenfranchised but also is not held accountable for the outcome. There is a need to create learning environments where teachers can move from being dependent to becoming self-directed learners who understand how they themselves learn, accept responsibility for their own learning paths, and are committed to 'learn about learning'. It is imperative, therefore, that learning environments promote autonomy, and that ownership and control of the learning process to determine the goals and purposes of learning is vested in the learner. A reconceptualisation of learning by teachers proves difficult, as the educational system itself generally does not encourage a proliferation of learning styles. In addition, educators are by and large not used to self-directed learning. They have been the 'successful products' of a system that has not promoted this style of learning, and they are now considered 'experts' in their particular field. They find it hard and personally threatening to break out of this mould (Cranton, 1996).. So it is scarcely surprising that a self-perpetuating cycle has developed that has resulted in our educators not becoming self-directed learners. Yet they are now expected to design Constructivist-learning environments for children (DES curriculum guidelines 1999) enabling "children to learn how to learn" (p.7), with "a wide range of approaches to learning" (p. 10) in which the child is an active agent in their own learning (p. 14) .

However teachers have not had an opportunity to immerse themselves in such Constructivist learning environments within the parameters of the 'inservice' programmes that generally have been designed for them. Nor have they been given the time to play, to get to know themselves as learners, to think, to reflect and to develop awareness and appreciation of other learning styles. Teachers need to experience Constructivist learning and to begin examining their practice in a sustained intervention. Otherwise, the cycle of the existing transmissive form of schooling will continue.

To take this a step further: what would it take for teachers to transform their practice to reflect what being digital can mean for learning? Answering this could make a deep and meaningful change not only in how teachers' learning is perceived, but also in the educational system as it now stands. In order to transform practice, we need to question existing practice, and to do so, we need to formulate a challenge to this practice. In the face of strong societal expectation of the traditional role of teachers, which influences and colours teachers' own understandings of their role, the challenge, is to find a sustainable means of supporting teachers who begin the process of trying to change their traditionally accepted role. The Empowering Minds project began with a vision of a learning environment where teachers not only are viewed as facilitators of learning and co-learners with their students, but are also accepted and respected as learners themselves, learners who become self-directed, understand how they themselves learn, and accept responsibility for their own learning paths.

To this end, rather than accepting the assumption that teachers need only be "talked at" or "exposed to" learning philosophies or theories, this study proposes that teachers need immersion in a supportive learning environment that promotes and encourages each individual to learn about learning. Teacher-learners are thus at the centre of a unique learning process arising directly out of their own experiences, needs, and interests.

Critical to the development of this culture of thinking and learning about learning is the exploration and innovative use of expressive computational materials informed by a Constructionist philosophy. Constructionism is grounded in the idea that people learn by actively *constructing* new knowledge, rather than by having information "poured" into their heads. Moreover, Constructionism asserts that people learn with particular effectiveness when they are engaged in constructing personally meaningful artefacts such as computer programs, animations, or robots that they can show and discuss with others (Papert, 1991, p.1). These artefacts are "objects to think with" and a means by which others can involve themselves in the thinking process. Given sufficient time and the appropriate supportive environments, teachers could construct their own understandings of what learning is, and develop productive learning environments for themselves and their students. Teachers could be actively involved as learners in the learning process. Community support enables a powerful learning environment, as other people are the greatest source of alternative views needed to stimulate new learning (von Glasersfeld, 1989). My study argues that using digital technologies within a supportive learning environment "makes it increasingly possible for ...[learners]...to engage in learning practices that lead to new ways of thinking, understanding, constructing knowledge and communicating results" (Milken Exchange, 1999, p.29). The central question that provided the focus of this dissertation was:

> Can immersion in a supportive Constructionist learning environment, rich in computationally expressive materials, challenge teachers to question assumptions and beliefs about their own and others' learning, and empower them to become self-determined learners with a critical awareness of what being digital can mean for learning?

I had to give careful consideration to the choice of computational materials to act as catalysts for thinking about learning. The computational materials needed to be (a) Conversational, encouraging feedback and negotiation; (b) Connective, promoting a personal relationship or connection to powerful ideas; and (c) Challenging, with no 'right' answers or more than one answer. The commercially-available LEGO Mindstorms product formed the core materials around which we developed Empowering Minds. Launched by the LEGO Group in 1998, this robotic construction kit is based on the Programmable Brick research at the MIT Media Lab. The programmable brick derives from the LEGO/Logo work done in the mid-1980's by Seymour Papert, Mitchel Resnick, Stephen Ocko, and Brian Silverman (Resnick & Ocko, 1990; Resnick, 1990).

But computational materials alone would not challenge teachers to think about learning. Nor would the materials motivate teachers to question their existing beliefs and assumptions, and lead to changes in their classroom practices. Using these computational materials, we designed an immersive environment in which this process of thinking about learning could begin. Because to "understand in a different way" increases potential for alternative actions, I believed that if teachers were to engage in challenging learning experiences that helped them understand their own learning processes, they would naturally see alternative ways of structuring learning environments for their students (Gadamer 1975, p. 297; Dunne 1992; Grundy 1987). We used an Atelier-style learning approach (Kuhn, 2001), underpinned by a Constructionist epistemology, to design the learning environments for the EM group. The Atelier model (see Chapter 3) is rooted in European traditions of artisanship: "It is a way of working that emphasises experimental production: building, crafting and demonstrating become ways of situating ...inquiries" (MLE Brochure, January 2002). A special strength of the Atelier style of working "is its ability to support multidisciplinary and integrative education" (Kuhn, 2000, p.5).

The choice of computational materials and the Atelier-style learning approach underpinned by a Constructionist epistemology would, I believed, "encourage dialogue, self-expression, community and reflection" and pose a challenge to the teachers' existing learning beliefs and assumptions (Ueda, 1999). The literature from adult learning suggests that adults' own personal needs and interests, coupled with their experiences, should form the starting point around which to challenge and build new ideas and perspectives on learning (Lindeman, 1926; Knowles, 1998). Drawing on these findings, I ensured that the teachers' own needs, interests and experiences informed the focus and direction of the emergent framework necessary for teacher learning.

However if teachers were to become self-determined learners, we had to address seriously the issue of sustainability. Teachers' understandings of learning are rooted in their classroom practice, so it would be natural to anchor their own learning to their everyday reality. The Empowering Minds model couples Atelier-style workshops with extensive support of the teachers' own learning styles, to enable the teachers to bring the computational materials and learning approaches into their own classrooms in their own way. Thus, teachers' own learning is explicitly linked to children's classroom learning. I believed that the changes and developments these teachers witnessed in the classroom would concretise their new understandings of learning, and would challenge their existing beliefs and assumptions. As a result, the teachers' classroom experiences would become their own richest source of learning, their "object to think with", (Papert, 1980, p.12 ; Turkle, 1995) and the lens through which they could begin to reflect upon and question what they understood as learning, and their own roles as teachers. If teachers from very different traditions really are to become the agents of their own learning and to engage in the social construction of knowledge, then certain structures, resources and policies also need to be in place in order to support this learning. Support structures (e.g., building activity in workshop format followed by reflective discussions, group meetings, classroom visits, cluster groups) need to be developed to form the framework for this valuing of classroom experiences, so the teachers will be able to continue to collaborate, reflect and critically evaluate their own learning and what happens within their classrooms. This 'knowledge of practice' places each teacher at the centre of their own problematic practice that develops over time with others in a learning community as a result of reflective inquiry (Cochran-Smith and Lytle, 1999; Schön, 1987).

The structure of this dissertation, which details how teachers began 'learning about learning' using expressive computational materials, is as follows. In Chapter Two, a dialogical scenario is presented, outlining the broader global context of the Irish Schools IT2000 initiative. Arguments representing alternate perspectives are developed as three representative characters debate policy recommendations necessary, in a digital context, for schools. They begin by reflecting on the implementation policy in Ireland merely to train teachers to integrate the use of digital technologies into the existing curriculum. To understand what may have influenced or shaped these decisions, they discuss the existing relationship between the nature of knowledge and the conceptualisations of learning, and the way in which these assumptions may colour the ways digital technologies currently are used in schools. This explication is followed by an examination of the intricate relationship between understandings of knowledge and their implications for learning, and the ways this relationship has influenced teacher development programmes. The dialogue concludes with a consideration of the conditions necessary for meaningful teacher learning, and of ways this consideration may impact classroom use of digital technologies.

Chapter Three first describes the design of the immersive learning context created for the teachers, which combined exploring expressive computational materials within an Atelier style learning environment. The features of the Atelier style of working are outlined, and the reasons for using it and the chosen computational materials are discussed. The second part of Chapter Three describes the challenge of sustaining this type of learning to enable teachers to become self-determined learners. The complex support framework that was developed in direct response to the teachers' expressed needs and interests is described and contextualised, using examples from a variety of settings. The overall picture of the EM project's development, and particular factors instrumental in shaping the general progress of teachers in embracing the computational materials and new ideas, help the reader contextualise the journeys of specific teachers described later in the individual case studies.

Chapter Four outlines the emergent research design and methodology I used in order to understand the learning processes and styles of the Empowering Minds teacher group and their emerging understandings of what being digital means in learning. Working with these teachers as a participant-observer in their natural settings, I rely upon qualitative research methods, as they are particularly suited to uncovering meanings people assign to their experiences (Hoshmand 1989; Polkinghorne 1988). I describe the interpretive methods (Erickson 1986) I employ for this exploratory study, and I detail the collection and interpretation of qualitative data over a five-year period. Also, I outline and explain the axial framework for describing a representative set of teachers' conceptualisations of learning as they embarked on the project, and the ways their understandings appear to have changed and developed over time.

The case studies of four teachers from the EM group are the heart of the thesis, and form the main focus of Chapter Five. To describe each teacher's unique set of experiences and their engagement over the lifetime of the project to date is impossible, and cannot effectively capture the wide variety of exciting learning experiences across the group. In order to depict teacher responses to the project, I develop four in-depth case studies by selecting a teacher from each of the quadrants of a simple axial framework. The axes forming the framework are learning epistemology (the continuum from Instructionism to Constructionism), and fluency with digital technologies (from no understanding or use, to high comfort level and use of digital technologies). This matrix illustrates the diversity of backgrounds and experiences the teachers brought to the project, and the ways their backgrounds and experiences affect their learning. Using a narrative approach, I try to capture these four teachers' emerging understanding of the process of learning using expressive computational materials, and the ways they have begun to question their beliefs and assumptions about learning. In each case study, I make the work come alive through the use of salient quotes and vignettes from field notes, interviews and observations.

In the final chapter, I consider the implications of this study and make recommendations for policy makers with regard to the development of a comprehensive approach to teacher learning.

# Chapter Two
# VOICES ON KNOWING, LEARNING AND DOING IN A DIGITAL CONTEXT

### *Setting the scene for the dialogue*

A small group of professionals has been brought together in order to and to advise on the development of the new three year policy for the use of digital technologies in Irish schools. The government are worried because even though they have funded increased the levels of hardware and connectivity in schools, they still see no significant evidence of appreciable gains in student learning (OECD, 2004). There are some exceptions to this observation, but innovative uses of the technology are few and far between. The majority of teachers still do not make significant use of these new technologies in their daily practice in classrooms (OECD, 2004; NCTE, 2004, pp.14-17; NCTE, 2003, pp.13-20; NPADC, 2001, pp.21-25). If the demand for inservice courses in this area is taken as an indicator, teachers are showing less, not more, interest in using technologies. (NCTE 2004, in press).

Budgetary constraints caused by a recent downturn in the economy mean that the government is reluctant to commit further investment without a thorough analysis of spending to date. Rather than adopt its usual practice of working internally and having its own ICT policy unit draw up policy documentation, the Department of Education and Science (DES) has been instructed by the government minister with responsibility for the "Information Society" to bring together a small group of professionals from a range of backgrounds and experiences to develop a well-informed explicit policy statement to inform government spending. In order to develop this statement, the group will examine developments in education since the announcement of Schools IT2000 (1997).

### *The Discussion Participants*

TE: Former teacher, currently a teacher educator with a strong research interest in teacher learning and digital technologies. Involved with a number of projects using expressive computational materials in a variety of schools.

CS: Computer scientist working in a school of computer applications; normally works with postgraduate computer science students, but also involved in a postgraduate programme for teachers using digital technologies

PE: Evaluator of school programmes using digital technologies, and a strong campaigner for teachers using action research. Staff member of National Centre for Technology in Education

## *The Discussion*

PE: It's hard to imagine a world without all the digital technologies we take for granted today. Everything we use now seems to have some chip embedded in it and we seem to be bombarded from every angle with "information" about just about anything you can imagine.

TE: Yes, it's interesting that you should remark on that. I was just thinking the very same thing this morning, when I was pouring milk on my cereal and noticed that there was a web address along the side of the carton indicating where I could go for more information about a healthy diet. On my way in here, I began to notice the number of web addresses on vans, trucks, hoardings. Even my take-away coffee had a web address that I could use to order my lunch and have it delivered to my desk. Then, I had having a few minutes to spare before we met, so I used my mobile connect card and my laptop, to pay my phone and credit card bills, check my bank balance, order my weekly household shopping to be delivered to my home and check out a number of companies for quotes for my car insurance which is due shortly – all on the Internet.

PE: You seem to make great use of the technology in managing your personal life.

TE: Yes, I suppose I do. I have greater control and it saves me enormous amounts of time in managing certain things. For example, I no longer have to queue for theatre tickets, and I can make airline and holiday reservations myself. But I do think that you have to consider why you use certain things, and whether they really do enhance the quality of your life. The individual, I believe, has to be the one who makes the decisions rather than being dictated to by outside forces. Sometimes I worry about who's controlling what!

CS: What do you mean?

TE: Well, take the task we've been charged with. I see it as having two components with a common thread. The first is a review of what has happened to date regarding the use of technology in education, and the second is to make recommendations for the future direction of educational policy. I'm uncomfortable with the idea of making decisions that will affect other peoples' lives unless I am happy that they are ultimately in control and can determine the direction of their own destiny. Consequently the common thread underlying these tasks for me is - who's in control?

CS: That's all very well in principle, but if you adopt that attitude to schools, how can you ensure equity and quality if everyone is off doing their own thing? There has to be some form of standards with examples of best practice documented and disseminated. Otherwise there would be bedlam!

PE: I don't think that a state of anarchy would develop. Difference is important and each teacher should be encouraged and supported to reflect on their practice "in action". Each teacher's practice will differ, but if there is a school-wide policy of engaging in this type of reflection on "knowledge in practice" (Cochran-Smith & Lytle, 1999, p. 262) then there can be consensus at a school level about policy issues and how best to deal with them.

TE: Does awareness of the system have to stop at the school level? Or do you think that teachers should be aware of wider societal issues? Should they always interact only with their colleagues within their own school? If they reflect only on their own practice without their assumptions and beliefs about learning ever being seriously challenged, is real change ever possible? Do you believe it is possible to think beyond the box without ever being forced out of the box?

CS: These are difficult questions for this time of the morning and I'm not really sure if they are relevant to what we have to do. What has philosophy got to do with technology anyway? How about we settle to the task in hand and review what has happened to date with Schools IT2000.

*Shuffling of papers, rummaging in brief cases for relevant documentation*

CS: It's hard to imagine that it's taken nearly twenty years for every school in the country to have access to computers, and that there's finally funding available from the DES for schools to purchase hardware and software.

PE: I hadn't realised that it had been that long.

TE: Yes, now that you mention it, I remember Department of Education and Science publishing a circular and a report on the use of computers back in the mid-1980's (DES, 1987). That was around the time I was doing my Master's research, focusing on problem-solving using Logo as part of an enrichment programme for mathematically talented children at St. Patrick's College. We had just bought a BBC-B computer for my school with funds the parents had raised. What was ironic at that time was that we could apply for a grant from the DES for a trolley to put the computer on as it was considered "school furniture", but we couldn't get any grant payment towards the cost of the computer.

CS: Isn't it strange, that there were no significant developments or support for using technologies in schools in Ireland until quite recently? Yet within a few short years so many governments issued policy statements about the use of digital technologies in schools during the 1990's !

PE: Why do you say that?

CS: Well, I was trying to get a sense of where Schools IT2000 fitted into the overall global picture. Take a look at this short list I jotted down last night after a quick search on the web. You'll see that there was a flurry of activity within a short time frame in the race to get action plans and policy statements published:

Singapore, 1992.
Sweden, 1997/8
USA, 1995 (O.T.A. 1995)
Netherlands, 1997
Finland, 1995
Ireland, 1998
UK, 1997

TE: It's not that strange, really, because if you take a look at some of the early starters it's no coincidence that they are among the dominant economic powers in the world. Increased globalisation has sharpened the race for greater economic dominance and efficiency. Today's post-industrial society sees information and the ability to apply it as the key generators of wealth and social development (Tiffin & Rajasingham, 1996). Even as early as 1983, the US's National Commission of Excellence in Education, said

> If only to keep and improve on the slim competitive edge we still retain in world markets, we must dedicate ourselves to the reform of our educational system for the benefit of all ...Learning is the indispensable investment required for success in the 'information age' we are entering (National Commission of Excellence in Education, 1983, pp. 5,7)

PE: So what you're saying is that many governments saw their education systems as among the key vehicles for mobilising and putting into effect this technological knowledge-based infrastructure.

TE: Exactly. Take, for example, Tony Blair, the British Prime Minister. He stated that education is the key to helping businesses compete and that "children cannot be effective in tomorrow's world if they are trained in yesterday's skills" (DfEE, 1997, Forward). To this end his government started putting a National Grid for Learning strategy in place to ensure that "by 2002, all schools will be connected to the superhighway, free of charge; half a million teachers will be trained: and ...children will be leaving school IT literate..." (DfEE, 1997, Forward). The British government's approach was not unique. Indeed, in many respects, Ireland followed suit, as you will see when we examine later how they implemented the Schools IT2000 policy document.

PE: But isn't this a very simplistic argument, to suggest that if you install hardware and provide some training students will be IT literate? There seems to be no questioning of what is appropriate hardware or training or any attempt to define what it means to be IT literate.

TE: Perhaps. But the emerging new Celtic Tiger had to pay heed to the developments of its stronger economic neighbours and rivals for survival. It was natural that countries like Ireland, who do not have significant quantities of exploitable natural resources, would see the emergence of new technologies as an opportunity to develop and capitalise on a knowledge-based infrastructure. In the race to consolidate economic progress during the last decade, there was an urgent call to action to address the question of how digital technologies were to be used in our education system.

PE: If I follow you correctly, what you are suggesting is that the world of economics was driving the initiative to begin using technologies in schools.

TE: Yes, and I would also suggest that the application of a business model informed the ways in which technologies were to be used in our educational system. The technologies that were and, indeed, still are valued are those that promote the access to information and the ability to communicate it quickly. This works well in the world of economics, as access to the latest information coupled with a fast communications network has brought larger profits, increased efficiency and ensured survival, in the global market place. An important maxim within the business world is "Time is money", so anything that saves time is worth investing in. I have here Louis Gerstner Jr.'s, 1995 address to the National Governor's Conference (1995) – he's IBM's Chief Executive Officer – which for me sums up the thinking of many who assumed that the same business model could be applied to our educational systems. Gerstner says, "The same changes that have brought cataclysmic change to every facet of business can improve the way we teach students and teachers. And it can also improve the efficiency and effectiveness of how we run our schools" (cited in Glennan & Melmed 1996, p.9).

Not surprisingly, in order to maintain and improve their economic welfare and survival chances, many governments concentrated on building the communications infrastructure and hardware within the educational system. Even the term ICT – Information and Communication Technologies – used to describe the technologies used in schools, clearly specifies the emphasis that schools were to make when using technologies. This model had served business well, so the assumption seems to have been that the same model would suit the school environment equally well, particularly as the main objective was to produce the IT literate student who would be effective in the development of the economy.

CS: In their defence, I think it was logical that governments concentrated on providing the hardware and infrastructure first. How else could anything be done?

TE: But what about the people within the education system? How and where do they figure in all this planning and activity? After all, there should be a balance between what Habermas has termed the "systemsworld" and the "lifeworld" (1985). Does it have to be a case of either/or? Can there be an initiative that takes account of both in a symbiotic relationship?

CS: Well, once the hardware was in place they could concentrate on what basic content the teachers needed, and organise training for them. Those who were interested in finding out more about the technology could pursue more advanced courses or postgraduate programmes in computer science.

TE: I have a problem with placing the hardware first without any consideration of the needs of the individual teachers and how the introduction of computers could impact on their practice. Reflecting upon current governmental policies of ICT provision of hardware, connectivity and training for teachers, the balance is heavily skewed towards Habermas' "systemsworld" rather than the "lifeworld," leading to change being externally imposed, decontexualised, and teachers feeling no control or ownership of these new digital tools. If, as you say, teachers just need the hardware and the technical skills, why then has there been no real groundswell of change in schools? Training in the use of the hardware is not sufficient. I believe the NCTE were very short-sighted in 1998 with their design of two twenty-hour basic ICT skills-based training courses for teachers (1998), which were then delivered throughout the country. The teachers were unquestionably enthusiastic about with coming to terms with the new technologies. You only have to look at the statistics I have here, to see that between 1998 and 2000, 70% of the teaching force voluntarily attended at least one of these short courses (Mulkeen 2002, p.2).

| 2000 data (1998 figures in brackets) | % of teachers who attended some course | % of schools that had training in the school | % of teachers with some computer skill | % of teachers with some Internet skill |
|---|---|---|---|---|
| **Primary schools** | 84 | 22 | 92 (76) | 74 (30) |
| **Second-level schools** | 65 | 67 | 77 (58) | 64 (34) |

This data which is available on the NCTE's website is derived from national surveys of all schools in 1998 and 2000 (NCTE 1998; NCTE 2000). The 1998 survey had a response rate of 97%, and the 2000 survey achieved 86%.

Perhaps if the "lifeworld" rather than the "systemsworld" were "placed firmly at the centre" and became the generative force, as Sergiovanni (2000 p.6) suggests, this could significantly change how teachers developed as learners and appropriated digital technologies

PE: Yes, I agree. Clearly, the need to understand and come to grips with digital technologies was a burning issue for the general teaching body. Teachers attended these pre-designed ICT courses were attended voluntarily and in their own time. They were trying to understand what these digital technologies could mean for their role as teachers. However, the value of this type of provision has long been questioned (Drury 1995; Fullan 1992, p.34) with teachers historically having a negative reaction to technically oriented courses that show them how to operate a computer but do not show them how to use computers to enhance their teaching (O.T.A., 1995, p.137). When this type of inservice provision is decontexualised, teachers cannot make connections with their own personal experiences. Teachers require time to reflect on the use of such equipment in the classroom environment. They need an element of action research – reflection in action – rather than just training built into programmes to allow them to integrate technologies into their existing classroom practices.

CS: Didn't the NCTE's Teaching Skills Initiative (TSI) unit later try to respond to teachers' needs when they developed a series of other short courses? For example, they had courses in designing school web pages, troubleshooting, network management, Internet usage and email. There was also some development of the narrow skills-based approach at primary school level as well, when teachers from the "ICT Talent Bank" of the INTO (Irish National Teachers Organisation) worked with the NCTE to design courses aimed at integrating the technologies into the revised primary curriculum (DES, 1999).

PE: Yes I will admit that there was some development of the original narrow approach. But all these courses were designed as stand-alone modules. They offered no ongoing support structure to help teachers as they experimented with the new digital technologies in their classrooms. All courses were developed and delivered using a train-the-trainers cascade approach. On the plus side all the trainers here in Ireland – in contrast to the UK experience – were teachers. They had no underlying economic agendas, such as promoting and selling a particular company's software. So our teacher-trainers very likely had a fuller understanding of the context of the course participants.

CS: Surely the teachers don't need their hands held all the time! They must have some responsibility for coming to terms with new technology. Once they've been given the necessary skills, is it not just a matter of having a new set of tools at their disposal to help them with what they do!

PE: No, they need to be involved in the process and make decisions that suit their circumstances. They require time and resources to come to their own terms with these new technologies and to see how they can enhance their practice by integrating these new tools into their classroom practice.

CS: But if you examine the programmes and activities of the NCTE I believe opportunities were provided for teachers to have some control over how technologies were deployed in their schools. Unlike other countries, take C2K (www.c2kni.org ) in Northern Ireland for example, the NCTE did not engage in centralised purchasing of hardware and software. Funding was made directly to the schools in the form of grant payments related to school type and number of pupils. Schools were free to choose the direction and focus of their development using digital technologies as they were totally at liberty to decide what hardware and software resources and materials they required to meet their own needs and demands. In addition to these grants, the Irish telecommunications company, *eircom,* donated a multimedia computer to each school with a free dial-up connection to the Internet, including line installation, ISP costs, and one hour per day of call costs for Internet usage.

PE: This is just focusing on the systems requirements. There was no effort to invest in the people within the system.

TE: There I must disagree. Funding was made available under the School's Integration Project (SIP; www.siponline.ie ) for teachers to develop innovative project ideas using digital technologies. Individuality and creativity were encouraged; funding was provided for hardware, software, and substitute cover for teachers attending specially developed workshops. Full or part-time project co-ordinators managed the projects and provided classroom support to the other teachers within the project. By 2000, 248 schools were involved in 48 SIP projects. When funding ceased in August 2001, there were 90 SIP projects in over 400 schools.

This type of pilot-project development was encouraged, as it was seen to have many advantages outlined as necessary to help teachers explore technology and integrate it into their practice, including the potential for teacher-teacher collaboration, which allows teachers to help each other to develop appropriate classroom practices for technology (Fullan, 1992, p36; Shayo et al., 2000). These pilot projects were also seen as a way of sharing control (Rogers, 1983, p. 333-5) and a means of allowing new ideas to develop at school level (Fullan, 1992, p. 47).

The NCTE also encouraged the sharing of ideas developed within these projects by organising a number of conferences (Galvin, 2002) for the teachers involved in the SIP projects. Also, they employed Jean Mc Niff, a leading figure in the field of action research, to host a number of workshops around the country, helping teachers reflect on their practice and the use of digital technologies within their projects. Additional separate workshops and discussions were hosted for the co-ordinators of large projects, to enable them to assist and support the teachers within their projects as they engaged in this reflection.

However, I am disappointed that since funding was withdrawn from the SIP initiative in August 200, the vast majority of the projects have ceased, with no new developments or interesting spin-offs from what was learned by the teachers. This was in spite of the fact that teachers were given the resources and time they sought coupled with the opportunity to develop their own ideas to meet with their own needs, interests and experiences. They also were able to share their experiences, at the regional and national levels. So what was missing?

PE: Well, maybe two years of support and funding is not enough.

TE: Maybe not. But I wonder whether that is the only answer. What is the thinking behind the policy rationale regarding funding? I see a series of interlocking powerful assumptions that "increasing access to computers in schools will lead to more classroom use which, in turn will transform teaching and learning to produce the desired outcomes in graduates and the economy" (Cuban, 2001, p. 34).

CS: Well, Becker (1999, p.15) did find some evidence that long-term access to technology was associated with teacher use of the technology in the classroom

TE: But technology use does not necessarily imply an improvement in student learning. Despite these findings, the drive towards increasing the amount of hardware in schools continued with the announcement of the government's "Blueprint for the Future of ICT in Irish Education" (DES, 2001). Out of the overall budget for 2001-2003 of €107.92 million, €78.72 million was spent on capital grant aid for first and second-level schools for the "development of wiring-networking infrastructure and the provision of broadband access to the Internet" (DES, 2001, p.5-6) To me, these policy decisions continue to assume that increasing access to new technologies will increase the effectiveness and efficiency of what was already being done in schools. Surely this categorises knowledge as information, a product that can be more effectively packaged using technologies and then transferred more efficiently into students' heads. There would be no questioning of existing practices, as teachers would continue to be trained.

Paradoxically teachers are recognised as the central facilitators of change in education, but a training programme is to be devised to meet specific needs identified by teachers themselves (DES, 2001, p.9). But what change is possible if teachers don't fundamentally question their existing beliefs and assumptions? What is more generally the case, as Scrimshaw (1997) found, is that teachers tend to incorporate ICT by adopting those elements that serve their existing teaching style, rather than changing to match the opportunities the technology may offer.

PE: No, if given adequate time, teachers could develop new classroom practices and be more aware of what they are doing and why they are using these new tools as they integrate them into the curriculum. Teachers then, perhaps would be more aware of the process of learning as they reflect on what they do rather than just focus on the product or what is learned.

TE: To be able to think about something in an innovative and creative way assumes you have had the right and opportunity to think in alternative directions and from a multitude of perspectives. However, the reality is that teachers are trained in the use of ICT rather than deciding for themselves effective and appropriate uses of a broad range of digital technologies, which are the current tools of society. If these digital tools are only to be used as integrating agents to bolster the existing educational system, I believe there is a danger of shutting off the possible potential they offer to think and develop learning in very different ways.

The focus is still on integration rather than reconceptualising or changing existing school practices, on improving what already exists, not on asking hard questions about reconceptualising how knowledge or learning is understood or structured. Papert (1991a, p.10). refers to this as "first impact" of the technologies "when 'computer literacy' is conceptualised as adding new content material to a traditional curriculum" This is understandable initially, as when "any new technology is invented it is first used to put a new twist on how people accomplish familiar tasks. It takes time for new technology to give rise to new practices and the new cultures that support them" (Caperton & Papert, 1999, p.3).

I believe that it is time now to move beyond this "first impact" stage and ask ourselves, "Why are digital technologies being so narrowly defined as an integrating agent with teachers being treated as a group to be 'trained' in their use? Why aren't teachers deciding for themselves what are the appropriate ways to use these new tools for learning?"

For this, we need to move beyond what Papert (1990) has termed "technocentric thinking" which focuses primarily on the technical object. Because the technology is new and not well understood a lot of people have tended "to think about the technology first and the education later, if at all" (Appleborne, 1996). The technology is uppermost in their thinking, entirely colouring their view. This technocentric thinking has lead to the presumption that digital technologies alone, particularly the computer, can have an 'effect' on the way people think and learn. But digital technologies do not have an independent existence. They are nothing without the values that people bestow on them by making judgements in order to decide how these technologies are to be used.

CS: But that is my point, exactly. I believe that it is each teacher's responsibility to incorporate these new technologies into their teaching. There is a body of knowledge and skill about the use of technologies for particular purposes. It's similar to providing the practitioner with a set of tools and they can choose whichever suits their purposes. It's up to each teacher to decide how best to use these tools.

PE: That suggests a body of knowledge that is independent of context, and that teachers are just consumers of this content rather than contributors to a pedagogical base about the use of new technologies in teaching. Through reflecting on their practice as they make use of these technologies, teachers can document their "knowing in action" (Schön, 1983, p.59) thus becoming active generators rather than passive consumers of knowledge.

TE: I agree that teachers should be actively involved in deciding how technologies should be used. But we should be very aware that we can use these digital technologies in many different ways; the choice is up to every individual and depends on their values. The ways people use these tools reveals their values and their true intentions. I think we need to ensure that teachers are not limited by their current restricted understandings and experience of digital technologies. There is an urgent need to develop teachers' thinking to the level of 'critical judgement' (Papert, 1990).

For example, if we believe that the learner constructs knowledge and that each individual is an active maker of their own meanings, then we need to empower learners to use and shape the world with these "convivial tools", rather than be shaped by them (Illich, 1974). We need to ask what these new tools will enable us to do, and what is worth doing? So we can't consider the question of how digital technologies are to be used in education in isolation, but we must view it according to our definition of the nature of knowledge and the nature of knowing. Concepts of learning and our understandings of knowledge are linked. We cannot possibly have a view of learning without also implying a view of knowledge.

The empiricist and rationalist traditions both view knowledge as an object, whether it is located inside or outside of the individual. In contrast, the Social Constructivists consider knowledge as a process with an intimate connection between knowledge and activity while also taking account of the contexts (social, historical and physical) of a learning situation. Consequently, knowledge is considered to be situated and distributed while learning is viewed as a social participatory process. Digital technologies do not have an independent existence and cannot be considered separately from the values that people bestow on them. So there is a consistency, explicit or implicit, between how people understand knowing and the nature of knowing and what technologies are valued and how they are used. The ways digital technologies may or may not be used reflect these understandings. Before considering how the use of digital technologies may influence learning, we must first examine what is defined and valued as knowledge and what is considered to be worth knowing.

CS: But how will this help make recommendations now about future policy regarding the use of digital technologies in schools? I'm not convinced that we have to delve as deeply as you are suggesting. Having listened to these arguments, I agree that in our policy recommendations we need to stress the restructuring of the inservice that has been provided for teachers to date in order to upskill them in the use of digital technologies. The DES was remiss in not providing inservice days as they did for other programmes such as RSE and the introduction of the revised new curriculum.

In hindsight, I realise that this action may have lead teachers to believe that becoming users of technology to ensure that future generations are computer literate was not important. They may not have realised that becoming computer literate was important for economic efficiency as knowledge has a limited shelf life in today's globalised world. Providing dedicated inservice days in the future will rectify this perception and also ensure that the non-adaptors will be made aware of the technologies. Models of best practice can help them understand how to implement the use of digital technologies in their own classrooms.

TE: Building in official time for teachers to take this inservice is a laudable recommendation. However, as Lierberman and Miller (1999) have indicated, this type of staff development does not acknowledge teachers' contributions to the knowledge base of learning. It endorses the perception of the policy makers' perception that teachers can easily adapt the use of digital technologies into their current teaching schedules, as if it would only be an extension of what they already do, they would just be using some new tools!

Inservice provision on these terms perpetuates the understanding that teacher professional development "is occasional, episodic and carries such connotations as teacher as expert who dispenses information to students thus perpetuating notions of learning as passive and teaching as teacher-centred" (Sugrue et al. 2001, p.8). It also encourages the mentality of the quick-fix and tips-for-teachers approach that leads to a mechanised, linear, one-size-fits-all understanding of teacher development. Courses are generally "delivered" by an "expert", "trainer" or "tutor", implying that knowledge has an external existence independent of individuals. The term, "inservice" also carries with it an undertone of prescription, implying that teachers will be assembled to order, and informed about a new policy that they will dutifully put into practice. In effect, this reduces teachers to technicians, or "cogs in the state apparatus of schooling" (Sugrue et al., 2001, p.7).

I believe this approach reflects a behaviouristic understanding of learning, and a perception of knowledge as something that is capable of being transmitted. Research informed by this paradigm tends to produce empirical evidence of what works, which manifests itself in lists for improvement and effectiveness while promoting the documentation and dissemination of best practice.

This is why I found the SIP initiative paradoxical. Although SIP provided funding at school level to encourage teachers to use the technology for initiatives driven from the grassroots, the results of the more successful projects were to be disseminated as examples of best practice. The potent danger "implicit in this stance is the notion that best practice is readily identifiable, can be verified and documented, and that it can be disseminated widely, thus perpetuating the notion of 'one fit' for all, independent of context in all of its ramifications" (Sugrue et al., 2001, p.15). It never asks, "Best practice? – For what and for whom?" Teachers have been supported in learning to implement innovations but not in assisting teachers in learning to innovate.

PE: I'm afraid I too disagree with your proposal to continue to develop generic courses to be delivered to teachers. This conception is characterised as a disciplines approach or "Knowledge for Practice" (Cochran-Smith and Lytle, 1999), which assumes a body of theoretical knowledge (subject-specific and subject-specific pedagogical knowledge) that teachers should know, and that teaching is merely the act of putting this knowledge into practice. Teachers are consequently perceived as knowledge users rather than knowledge producers. Closely tied to the Empiricist understanding of knowledge, this is a "standards-based" (student achievement and/or teacher competencies) approach to school reform that views teachers merely as passive consumers of research and transfer of training becomes a goal for in-service programmes.

This outmoded training design of "theory, demonstration, and practice" dominated staff development programmes for teachers during the 1970s (Joyce and Showers, 1980). The many critics of this perspective have labelled it technical-rational (Schön, 1983) and positivistic (Lincoln and Guba, 1985). Ruiz and colleagues have argued that efforts at school reform which subscribe to this conceptualisation generally have resulted in top-down policy mandates, with minimal training and no long term follow-up support or feedback to classroom teachers (Ruiz et al., 1995). Many of these "fad stampedes" have resulted in "herd-like swings in educational policy and practice" (Sergiovanni, 1999 , p.76). This has resulted in a tendency to promote the "one best way" prescription for all schools, "regardless of local traditions, values, needs and interests" (Sergiovanni, 1999 , p.76). Consequently it is not surprising that staff development in the form of "one shot" workshops have been mostly ineffective in promoting new teaching behaviours and the confidence that is required to initiate change (Showers & Joyce 1996).

CS: So what do you propose we should recommend instead?

PE: We won't go far enough if all we do is build in time for teachers to take predetermined courses. It is crucial that they have the opportunity to reflect on their practice, which they can do on their own or, more productively, with a trusted colleague or in small groups. Teachers need to be actively engaged in their own re-education by engaging in appropriate reflective action. Darling-Hammond and McLaughlin argue that "professional development today ... means providing occasions for teachers to reflect critically on their practice and to fashion new knowledge and beliefs about content, pedagogy and learners"( Darling-Hammond and McLaughlin, 1995, p.597). They claim such an approach will lead to "a learner-centred view of teaching and a career-long conception of teachers' learning" (p.604).

This perspective differs from the "knowledge for practice" (Cochran-Smith & Lytle, 1999) conceptualisation in that teacher "knowing in action" (Schön, 1983, 1987) is acknowledged and valued. Here, teachers are viewed as knowledge generators, as makers of meaning rather than consumers and implementers of knowledge generated by experts. We must pay close attention to the context in which teachers' thinking and action are shaped. The locus of change is at the level of the school; it's not centralised and implemented in a top-down fashion. The "school as a unit, as an organization, is more amenable to reform than an entire system, and ...teachers are active agents of the reform process" (Sugrue et al., 2001 p.21). So, schools become the "sites and sources of learning" for teachers as well as students (McLaughlin, 2001; Barth, 1990; Darling-Hammond, and McLaughlin, 1995; Lieberman and McLaughlin, 1999).

To facilitate this development funds could be devolved from central administration to allow schools to manage ICT integration locally. To some extent, the NCTE does this already, in that capital grant funding is allocated on a school basis. But we could extend this to include professional development for ICT at whole-school level. We would have to build time into any proposed programme, to facilitate meaningful collaboration. Rather than the dissemination of best practice schools could take a lead from the qualitative research community over the past two decades, and systematically try to document this teacher knowledge, predominantly in the form of teacher narrative. Some examples of this in the Irish context are the action research work of Mc Niff, Mc Namara & Leonard (1998) and Mc Niff & Collins (1994).

CS: I take your point. I am not implying that everyone need march to the same tune at the same time. I understand that there is a wide diversity of experience across schools, and some are more prepared than others. However, we still need a wide selection of courses so schools can choose from the range available, as they require. A hierarchy of courses would let teachers could build up their skills in a logical fashion. I like your idea of having the inservice school-based, as this circumvents the concern I have about some teachers not being exposed to the technology, and best practice examples of its uses in teaching.

TE: Well, I have serious reservations about predetermined course packages that exemplify and support best practice. However, I do agree that the teacher's "knowing in action" should be acknowledged and valued. The literature on adult learning (Lindeman, 1926) would suggest that adults' own personal needs and interests, coupled with their experiences, should form the starting point around which to challenge and build new ideas and perspectives on learning. So it is important that teachers' classroom experiences and knowing in action should form a central part of their professional development. Social Constructivist researchers would also suggest that a focus on context is necessary as "our thinking is contextualised (constrained, enhanced and controlled by a context) because we choose to belong to or are born into social groups" (Gage & Berliner, 1998, p.297).

We must confront the danger of restricting this context to a single school focus as you suggest, particularly if we consider that this culture determines the tools we use as we grapple with the realities we encounter in our environments. Bruner (1973, p. 22), for example, saw thinking as the "internalisation of 'tools' provided by a given culture", while Vygotsky (1978) believed changes in tools bring about changes in thinking, and that these changes in turn are associated with changes in culture. This is a reciprocal relationship. This connection between the tools a culture uses and how its thinking develops is critical when one is deciding how digital technologies (today's tools of society) are to be used.

We need to be mindful of several fundamental questions: Is the type and use of digital technologies being decided upon and driven purely by the economic interests of dominant groups in society? Will these tools be used to maintain the status quo in our educational system? Or can we harness them and use them creatively to empower people to create very different learning environment for themselves and others?

The answer to these questions, I believe, very much depends on how we conceptualise teachers' learning, or what is more commonly referred to as "teacher professional development". If we look at the different conceptualisations of teacher learning, we see the close relationship between underlying epistemological assumptions and the type of teacher professional development programmes that emerge. The design of such teacher programmes will not only have direct implications for how teachers will use these new digital technologies, but it may also challenge existing learning environments and what is presently valued within our school systems.

CS: How can you make such claims?

TE: Easily! Conceptions of teacher professional development are inextricably linked to perceptions and understandings of how knowledge is structured. However, this link between how knowledge is understood and valued and how teacher development programmes are conceptualised has generally not been acknowledged or articulated. So there has been fragmentation and a lack of coherence. I am not alone in this claim. Other researchers have observed:

> Professional development for teachers has a poor track record because it lacks a theoretical base and coherent focus. On the one hand, professional development is treated as a vague panacea- the teacher as continuous, lifelong learner. Stated as such, it has little practical meaning. On the other hand, professional development is defined too narrowly and becomes artificially detached from "real-time" learning. It becomes the workshop, or possibly the ongoing series of professional development sessions. In either case, it fails to have a sustained cumulative impact (Fullan,1995, cited in Guskey and Huberman, 1995, p. 253).

The Irish White Paper on Education (1995) also recognised that professional development for teachers was fragmented and seriously hampered because it depended on the voluntary participation of teachers in almost exclusively provider-driven courses. Despite these findings, the Schools IT2000 programme for teachers was totally dependent on the voluntary participation of teachers and was very much provider driven, as the courses were developed by a central agency (NCTE) and delivered to all participants regardless of individual teachers' context, experience, needs or interests.

This practice cannot go on. While the teacher is one of the key players in structuring the learning environment in our schools, their ability to do so depends on their own learning experiences and what they have come to value as worth learning. For this reason, we must turn our attention to how teachers learn, and the experiences they have shaped their beliefs and understandings of what is worth knowing and how one comes to know as this will colour – and whether – they use digital technologies. We must articulate, clearly and coherently, the epistemological base that informs professional development programmes for teachers. If the reflective process you propose is constrained by the practice on which it is based, I ask you sincerely, "How can teachers really grow if they never challenge their assumptions and beliefs about learning"?

Taken to the extreme, the approach you suggest can perhaps be accused of being an over- indulgent case of "navel gazing". If we narrow the reflective process to teachers' practice alone, without reference to the bigger social context, or questioning what and why certain types of learning are valued within the existing system we deny the larger societal forces that determine and define what school is. We must demonstrate a more "explicit recognition, therefore, that schooling does not exist and function in a vacuum but is connected to larger social forces so that being a teacher requires engaging with these wider movements towards democratic, just and equitable ends" (Sugrue et al., 2001,p.27).

The whole-school focus is also problematic, as it is difficult if not impossible to mandate collaboration among teachers in a school, due not least the jealously guarded "legendary autonomy" of teachers in the Irish education system (OECD, 1991). Teachers who hold such strong beliefs of professional autonomy and identity, often view seeking the co-operation and collaboration of colleagues as a weakness rather than strength and a willingness to learn (Sugrue, 1996, 1997). But, as Peter Senge (O'Neill, 1995) noted, nothing in schools or other organisations will change unless individuals change. They have to change beliefs, ways of seeing the world, skills and capabilities in an environment conducive to change.

So, we must turn our attention to how teachers learn and the experiences they have had to shape their beliefs and understandings of what is worth knowing and how you come to know as this will colour how they use digital technologies – if at all. The question we need to ask ourselves is: "How can we move beyond what Papert has termed 'the first impact' of the technology?" This is the challenge I believe we are facing when we are asked to make recommendations to policy makers about how digital technologies are to be used in our schools. If it is acceptable that everyone (including teachers) is in control of, and agents of, their own learning, then this implies that all learners are at the centre of the process, and the responsibility for this learning is at their feet. However, certain structures, resources and policies also need to be put in place in order to support this learning, if in fact teachers who have come from very different traditions are really to become the agents of their own learning, engaging in the social construction of knowledge.

CS: These are lofty aspirations – but are they realistic? How do we begin to put policy recommendations together if everyone is basically off doing their own thing with no core foundations or standards?

TE: If the teacher really is to be regarded as the agent of change with the introduction of these new digital technologies, I believe it is vitally important that the teacher be regarded as an active learner rather than someone who can be trained to integrate their use into the existing curriculum. For teachers to move to building powerful learning environments, there has to be a shift in the thinking behind teacher professional development programmes. Unless teachers themselves are active in constructing their own understandings and meanings on an ongoing basis, within the framework of a supportive learning community, how can they possibly nurture other learners? In turning our attention to focus on teachers' learning, we must ask ourselves probing questions including: How do teachers learn? Do they learn in the same ways as children? Are teachers and children's learning needs perceived as being different?

Initially, an examination of the literature on adult learning could provide some indicators of appropriate factors to consider when designing a learning environment for adults. In tandem with this, the literature on teacher professional development should highlight key components identified to facilitate meaningful, long lasting teacher change.

*With some stated reservations about the usefulness of engaging in such activity, the group decided to adjourn for the remainder of the day to read around these areas. It was also agreed that relevant articles or informative writing that illustrated key ideas should be exchanged by email before convening for the next scheduled meeting.*

CS: Despite my earlier misgivings I must admit that I enjoyed reading round the area of adult learning. I never get the chance generally to read beyond my own area of computer science, so it was refreshing to engage with a totally new discipline. What I found interesting was that there had been relatively little thinking or writing about adult learning until the mid-1920's. Most researchers were interested in how children learned and in the development of pedagogy. I always thought of the term "pedagogy" as a generic label for teaching methodology, but now I have learned that it refers to the art and science of teaching children, whereas "andragogy" is the term used to refer to the integrated framework of adult learning. The work of Malcolm Knowles, the pioneer in the field of andragogy, provides clarification and insight into the nature of this word and its meaning.

PE: Did you get a chance to access the link I sent to you that is dedicated to the purpose of examining the meaning of the word "andragogy"? (http://staff.fanshawec.on.ca/TGedies/andragogy.htm)

CS: Yes, and I found that if you just delete the last word of the url, it links back to a set of resources, (http://staff.fanshawec.on.ca/TGedies) that enabled me to get a good grasp of some of the main ideas in this field.

PE: What struck me as interesting is the similarity between the problems the early adult researchers and the task we are charged with.

CS: Your logic escapes me. What similarities did you recognise?

PE: Well, it is often a crisis that forces us to re-examine the ideas and /or practices we have been engaged in have accepted as normal. Just as today's rapidly changing digitised world challenges us to critically examine questions related to education and learning, it was in the radically changed post-World War I society that the different characteristics of adult learners began to be investigated. A spotlight was focused on adult learning as there was an urgent need to reintegrate the increasing numbers of returning war veterans for civilian life in the new social order. Investigations were accelerated with the establishment in 1926 of the U.S. the American Association for Adult Education and the debate on how adults learn began in earnest. This questioning caused our beliefs and subsequent expectations of adult learning to change over time. For example, today we accept that adults have the ability to continue learning throughout their lifetime. Indeed, it is expected that adults will change direction in their careers a number of times, so adults will have to continue to learn in order to adapt to their new careers. Indeed, the report by the Information Society commission to the Irish government states clearly that "workers at all levels in the 21st century knowledge society will need to be lifelong learners, adapting continuously to changed opportunities, work practices, business models and forms of economic and social organisation. In this changing environment, holding the status quo is not an option" (Information Society Commission, 2002).

However, the early investigators such as Thorndike (1928), had to actually demonstrate that adults had the capacity to engage in lifelong learning. What could be more dehumanising and limiting than to be regarded as having reached your learning potential once you reached adulthood? Sorenson (1938), on the other hand, concentrated on the processes of adult learners, producing evidence to support the idea that adults possessed abilities different from those of children. But, when we consider his findings, I think we have to question whether the abilities that he uncovered are in fact age-dependent and develop as a natural part of maturation. We also have to consider whether the learners, both children and adults, were treated in the same respectful manner and whether the context in which the learning took place equally challenging and motivating?

TE: While it is important to be aware of the environment in which learning can take place, and which environments are more conducive to learning, we must also ask questions about what is to be learned and whose decision it is to learn it. It is not enough to address the how we learn without reference to what is to be learnt. Of course, this brings us back to our previous discussions about knowledge and whether we consider it to be a product that is fixed and transmissible or a process that is constructed and negotiated in a social context.

Leaving aside the thorny question of the "what" for now, and focusing on the "how", we see vast differences in how learners are treated. This perhaps is related to how the learner is perceived. Generally, when adults learn, they are making a conscious decision to understand or come to terms with some problem they are experiencing, or they want to make a change in career or out of some strong personal interest or desire. The critical condition here is a motivated personal decision, which means that the adult learner has ownership and control of the learning.

This is very different to the situation as experienced by the majority of children where they are at the receiving end of a transmissive system that does not allow them any ownership or control over what they are to learn or how they are to learn it. From the outset, then, in many situations, it is not appropriate to compare adult learning with children's learning, as the situations are very different.

What is even more flawed and less honest is to compare systems where the adult content is prescribed, but the adult learner is treated in a more respectful manner than the child is, just by virtue of the fact that they are an adult, and that coercion, however subtle, is regarded as insulting to the adult intelligence. It is paradoxical that children's learning and adult learning excluding teachers – are generally considered as very different activities, with the adult population seen as having more rights and control over their own learning, just by virtue of the fact that they are adult. Perhaps this is an historical consequence of societal views about children. A major indicator of this undervaluing of children's rights is the fact that it was not until 20th November 1989 that the Convention of the Rights of the Child (http://www0.un.org/cyberschoolbus/treaties/childrens.asp) was adopted and opened for signature, ratification and accession by General Assembly (http://www.unhchr.ch/html/menu2/6/crc/treaties/crc.htm ) of the United Nations.

This type of thinking still colours the lens through which many view children's learning, and perhaps is responsible for the continued unwillingness to invest control and ownership of the learning process in the child. However, what is even more puzzling is that teacher learning has not been regarded in the same light as adult learning, despite the fact that teachers are adults. Teachers have not been treated with the same respect and rights to decide what is to be learned and how it should be pursued, as a systems perspective has always dictated this and has been imposed from the top down. It seems that adult learners – with the exception of the group of adults who are teachers – can expect certain conditions for learning, and that children are to be treated as not having the same rights as adult learners.

CS: In light of what you've just outlined about the historical context and how children were viewed, I now understand why Lindeman stressed that "...in adult education the curriculum is built around the student's needs and interests" (Lindeman, 1926, pp.8-9). Now I see why Lindeman also argued that texts and teachers play a secondary role in adult education and must give way to the primary importance of the learners' experience as in, "experience is the adult learner's living textbook" (pp.9-10). The fact that learning was pleasurable and contributed to the learner's self-esteem was also highlighted as an important factor in motivating learners (Tough, 1979).

PE: The thinking around adults learning continued to develop and was in direct contrast to the conventional education system which required the younger learners to knuckle down to an established curriculum over which they or their teachers had no influence or control. Lindeman's findings together with the works of educationalists such as Bruner (1977) and Cross (1981) strongly contribute to the principles outlined by Knowles (Knowles, 1998, p.62-63) on which adult learning is currently understood. I've printed out a copy of these for each of you, if you want to comment on them and perhaps use them as a framework for bringing together any of the other ideas you may have or came across while reading:

1. Adults need to know why they need to learn something before undertaking to learn it.
2. Adults have a concept of being responsible for their own decisions and are capable of self-direction.
3. The wealth of experience that adults have accumulated should be used to enhance learning experiences.
4. The readiness of the adult to learn is critical for moving from one developmental stage to another.
5. Adult's orientation to learning is life-centred rather than subject- centred.
6. The motivation of adults to learn is more responsive to internal rather than external motivators.

TE: Well, I see items 1 and 2 in the list as being connected because to make a decision, you need to have a rationale on which the decision has been based. Having the right to make a decision carries with it taking responsibility for accepting the consequences of that decision. So the control and ownership of the learning process rests with the learner who is consequently self-directing.

Freire (1972) refers to the principle that adults "need to know" as "consciousness-raising" and implies that adults should be engaged in a collaborative planning process for their learning. Tannenbaum, Mathieu, Salas and Cannon-Bowers (1991) have also indicated the importance of understanding participants' expectations through mutual planning. Coupled with this collaborative planning is the understanding that adults have a concept of being responsible for their own decisions, so adult educators need to treat them as being capable of such self-direction. They need to create learning environments where learners can move from being dependence to self-direction. To Candy (1991), being capable of self-direction implied personal autonomy, self-management, learner control and autodidaxy (intentional self-education). It is imperative, therefore, that the learning environments promotes autonomy, and that ownership and control of the learning process is vested in the learner.

PE: This learner-centred focus is evident in item 3, too, which stresses that previous experiences should inform learning experiences. Leigh also highlights the importance of the learner's experience and views learning "as a lifelong process beginning at birth and ending only with death, a process related at all points to the life experience of the individual....a process in which the student is an active participant rather than passive recipient" (Leigh cited in Knowles, 1998 p.42). So the adult educator places greater emphasis on individual differences and on using the learners' accumulated experience to enhance learning. Promoting the importance of experience as the richest source for adult learning and the need for adults to be self-directing in their learning has implications for the role of the teacher of adults. The teacher's knowledge is only as important as the learner's experience so rather than being a transmitter of knowledge the teacher becomes a guide who also participates in the learning.

TE: However, we must be aware the adult learner's accumulated wealth of experience can be a double-edged sword. It can either enhance the learning situation, or possibly inhibit it, as minds can be closed to new ideas and ways of thinking. Therefore, the readiness of the adult to learn is also closely tied with the adult's orientation to learning as they "become ready to learn those things they need to know and be able to do in order to cope effectively with real-life situations" (Knowles, 1998, p.67). The adult's orientation to learning thus tends to be life-centred rather than subject-centred, as adults cope most effectively when new knowledge, skills and attitudes are presented in the context of application to real-life situations.

For teachers, I believe this would mean that any proposed change or professional development programme would have to be embedded in the context of their daily practice in the classroom. This is increasingly important when considering that motivation for adults to learn is related not only to success, volition, value and enjoyment (Wlodowski, 1985) but also the belief that they can learn the material, that the learning will help them and that it is important to them (Vroom, 1994). This brings into play the idea that learning is also affected by emotions, attitudes and beliefs and these must be considered seriously when trying to construct a meaningful learning environment. Learners should feel safe (Maslow 1972) as real learning involves risk taking. Carl Rogers (Rogers, 1969) suggests that learning should be personally meaningful and relevant, as a person learns only those things that they perceive as being involved in the enhancement of self. He proposed that often learning is perceived as a threat to the learner's self-organisation, which can result in rigidity and resistance. So the learning environment must be extremely supportive, to encourage a relaxation of the learners' boundaries and enable them to feel free from threat.

While being mindful of these ideas, we also need to remember that not everyone learns in the same way, and different people will demonstrate different strategies depending on the context and the problem they are trying to understand. So we need to promote flexibility in approach and a means of sharing these learning strategies. A number of different learning styles (http://ase.tufts.edu/cae/occasional_papers/l-style.htm) have been categorised in the literature. These classifications of learners and dimensions of learning include:

1. Kolb (1984) - divergers, convergers, accommodators, or assimilators
2. Honey and Munford (1992) - activists, reflectors, theorists and pragmatists
3. Felder (http://www.ncsu.edu/felder-public/RMF.html) & Silverman (1988) and Soloman & Felder - )- active-reflective, sensing-intuitive, visual-verbal, and sequential-global (http://www.uncw.edu/cte/soloman_felder.htm )
4. Riding and Raynor (1998) - holistic, analytic, verbal, imagery

Educational policy documents have acknowledged individual difference and teachers are expected to be aware of different categories of learners and learning styles in their classrooms. The 1971 primary school curriculum was based on a philosophy incorporating the principle of "the importance of making due allowance for individual difference" ( DES, 1999, p.6 ; Rialtas na hÉireann, 1971, p.19). The Revised Primary School curriculum redefines this principle in the broader concepts of celebrating the uniqueness of the child and ensuring the development of the child's full potential as a unique individual (DES, 1999, p.8). Teachers are encouraged to plan and design learning environments that recognise and satisfy "the range of individual difference" that "should be taken into account in the learning process" (DES, 1999, p. 9). So teachers must construct learning environments that respect, value and share differences. They should provide opportunities for the learner to choose to work with a group or alone, to think globally, holistically or sequentially, using a variety of materials and media to engage in experiential learning that encourages innovation and discovery.

But, the professional development programmes teachers generally have experienced do not reflect these principles of learning. Although teachers are adults they are denied the status of the self-directing adult learner and their experiences in the classroom are not taken into consideration when authorities decide it's time for a change to be introduced into the system. Teachers are expected to accept mandated change (e.g., the introduction and use of digital technologies in the classroom) and implement it according to directives. But I believe what the researchers of andragogy proposed as necessary for adult learning could be considered appropriate for all learners and is consistent with the philosophy of the Social Constructivist and situated theories of learning.

CS: Can you summarise these principles of learning for me?

TE: Basically, I believe

- learners should have a voice in what is to be learned;
- their needs and interests should be addressed and their experiences be valued and considered a rich source for learning;
- they should be active participants rather than passive recipients;
- learning should be pleasurable even fun and contribute to the development of self-esteem;
- the relationship between teacher and learner should be a more equitable, shared experience, with both involved and participating in the learning process together;
- and control of the learning process should be vested in the learner.

CS: Isn't it strange that when adult education first became popular in the early 1900s, it was assumed that the same methods and techniques used to teach children could also be applied to adults? Now you're proposing to turn that on its head! You want to treat children as adult learners.

TE: Yes! But not only children, I suggest all learners – including teachers.

PE: Why, then are learning environments in schools today are very different to what is described above? With adult learning treated so differently from children's learning and teacher development programmes?

TE: Perhaps because teaching principles are based more on how people think children or adults learn and what they should learn, rather than on how they actually do learn. Shuell (2001) would agree with this observation as he argues that:

> Schools and educational programs are far more likely to be based on philosophical presumptions than on empirical and theoretical foundations of learning. School differ in their philosophical beliefs about human nature, children, locus of authority and knowledge, as well as beliefs about the nature of teacher and learning. Every educational system and instructional program contains a theory of learning although this theoretical foundation usually is implicit (Shuell, 2001 p.10).

As psychology developed as a social science, many theories as to how people might best learn developed in the latter half of the 20th century, which in turn influenced early teaching theory. For example, "traditionally learning was defined in terms of a change in a person's behavior, knowledge or ability to perform some task (including intellectual tasks)" (Shuell, 2001 p.2). Theories of teaching were subsequently developed that emphasised management of procedures leading to behavioural changes that were viewed as products of learning (Skinner, 1973 and Gagne, 1977). The main role of the teacher was that of someone who shapes behaviour.

This is in stark contrast to the principles of teaching derived from theorists who based their work on studies of adults, and who were predominantly informed by a Social Constructivist theory of learning. This perspective views knowledge as something that the learner constructs rather than assimilates, and the learner is recognised as being active and self-regulated. Consequently, Carl Rogers (1969) defined the role of the teacher as that of a facilitator of learning. He believed that the facilitator should show qualities of genuineness, caring and respect, and empathic understanding together with sensitive and accurate listening. The learner should control the direction of the learning according to purposes that have meaning for the learner; the facilitator should organise and make readily available the widest possible range of resources for this learning. The facilitators become participant learners and consider themselves flexible resources within the group. This view of the teacher is more in keeping with Dewey's work in the early 1900's, when he identified experience as the key starting point of an educational process informed by democracy, continuity and interaction.

PE: So you are suggesting that the contradictory teaching roles for the adult and child learner seemed to stem from the perceptions that different groups of learners – adults and children – learned in very different ways. But how do you explain the paradoxical conflict between the philosophical underpinnings of the curriculum documentation and classroom practice?

TE: Although the present Primary School Curriculum "gives prominence to the constructivist approach" (DES, 1999 p.47) this in itself does not ensure consistency between the underlying theory of learning and actual classroom practice. How individual teachers understand the learner and the learning process is of critical importance; it cannot be overemphasised, as it shapes how they construct a learning environment. For "it can be assumed that the learning theory subscribed to by a teacher will influence his or her teaching" (Knowles, 1998, p.73).

If a teacher constructs a learning environment on a restrictive "meaning perspective" (Cranton, 1996) then the environment will not foster learning for all learners. Cranton defined "meaning perspective" as the "framework that shapes our perceptions of ourselves, others and our surroundings. Meaning perspectives are formed through experiences" (p. 96). Educators need to be aware of their own meaning perspectives and to question them critically, on a continual basis. This constant questioning and revision of perspectives on practice is a self-directed process, which Cranton believes is "the essence of professional development for educators". She argues that "learning and development for … educators can be a process of questioning our beliefs about and perspectives on our practice" (p. 116).

Developing this idea, I believe that all educators must be in control of this self-directed process. However, this should not be carried out in isolation but should be informed by the stimulation and involvement of others. But as Cranton points out, educators are generally not used to self-directed learning, as they have been the successful products of a system that did not promote this style of learning and they are now considered as experts in their particular fields. So they find it hard and personally threatening to break out of this mould and it is hardly surprising that a self-perpetuating cycle has developed, a cycle that has resulted in our educators not becoming self-directed learners. This may help us understanding why teachers continue to integrate digital technologies into existing curriculum rather than developing new practices.

I think the question we should be focusing on now, in order to advise on future policy for the promotion of the use of digital technologies within our schools is, "How best can teachers be encouraged and supported to become self-directed learners? What type of professional development programmes would foster this autonomy in teachers to take control of their own learning?"

CS: Taking such an approach would mean turning the system, as we know it on its head.

TE: Well, perhaps that's what's needed. We need to stop tinkering around with the system and start to asking ourselves some fundamental questions about why the use of digital technologies in teaching and learning within our school system has not moved beyond integration within the existing curriculum. The key, I believe, is teacher learning. I agree with Corcoran (1995) that the typical formats for staff development are generally a waste of time, as they lack a clear focus and effective follow-up. More important, they are not part of a more long-range scheme of learning for teachers.

It takes more than a workshop to truly develop teachers' new abilities because "reform efforts that hope to build capacity must use a wide range of strategies" (Floden, Goerttz and O'Day, 1995, p.20). These ought to include time for discussion, observation and reflection. Perhaps a more problem-based approach to teachers' learning built on teachers' experiences and their ongoing classroom work in collaboration with colleagues would encourage a questioning of their individual "meaning perspectives" and initiate the process of becoming self-determined learners. Such an approach would include opportunities for reflective thinking and engaging in collaborative inquiry to support the development of the skills and confidence to support teacher change (Darling-Hammond 1996; Hamilton & Richardson 1995). These approaches would also help teachers become aware of and enhance their understanding of their students' learning styles and needs, as well as developing the teacher's capacity to analyse what occurs in the classroom.

Time to engage in such observation, analysis and reflection is essential, as large scale studies have found that changes in teachers' belief systems occur when they can attribute growth in students' learning to changes in their classroom practices (Guskey, 1986). Robert Lindberg (1995) reminds us that although belief must underlie a permanent change in human behaviour, belief is most likely to follow behaviour rather than to precede it. Therefore, getting individuals to take action or to behave in certain ways is perhaps a more efficient starting point than trying to change beliefs so that behaviour will follow. But action must be coupled with a supportive environment.

PE: This is a point on which I concur and support you empathetically as I wholeheartedly believe that ongoing collegial support is a necessary component to meaningful and long lasting teacher change (Showers & Joyce, 1996; Darling-Hammond, 1996; Caccia, 1996; Raywid, 1993; Ruiz et al., 1995. Rosenholtz (1989) maintained that teachers who felt supported in their own ongoing learning and classroom practice were more committed and effective than those who felt isolated and without support. This is especially true when coupled with the opportunity for reflective thinking: "It seems that when opportunities are provided for teachers to dialogue with colleagues in an atmosphere that promotes trust and risk-taking over an extended period of time, increased classroom implementation of new teaching strategies and behaviours results" (Zetlin et. al. 1998, p.3). Hord stressed that supportive conditions will determine "*when* and *where* and *how* the staff regularly comes together as a unit to do the learning, decision making, problem solving and creative work that characterise a professional learning community" (Hord, 1997, p.13)

However, the support does not have to come from the school level exclusively, as teacher networks and cooperation among colleagues are effective means of providing this support. McLaughlin and Talbert (1993) found that when experienced teachers had opportunities for collaborative inquiry, they generated a body of wisdom about teaching that could be widely shared to provide support among the network members. Mc Laughlin and Talbert also maintained that support from such teachers' groups and professional communities not only offered "the most effective unit of intervention and powerful opportunity for reform" (1993, p.18), but also that "participation in a professional community...supports the risk-taking and struggle entailed in transforming practice" (p. 15).

However, lack of support has been one of the key elements missing from most initiatives targeted at introducing teachers to using digital technologies. This is not uncommon in teacher development initiatives. As Bolam has observed, "Opportunities for professional development are all over the place. Unfortunately, many of them have no connection to what you do in the classroom. Others give you no support when you try to implement their ideas" (Bolam, 2000, p. 278).

TE: That comment resonates with me, particularly when I think of the many well-intentioned programmes when individuals or groups sometimes have come into an area / region bringing with them some world-renowned figures, bright researchers, sometimes even supported with lots of materials and equipment, firing the teachers' imaginations with lots of exciting possibilities!

But then they disappear and the teachers are left to work it out for themselves, frustrated with no ongoing support in a pretty much unchanged context. Many believe that "because, in so many cases, teachers effectively teach themselves to teach, they assume that they can teach themselves to teach otherwise" (Guskey and Huberman, 1995, p.217).

However, there is very clear consensus in the literature that the promotion of teacher learning requires sustained support from a variety of perspectives. Teachers need this sustained support to unlearn deeply-embedded routines in a complex environment. Time and again, the literature points to the need for expert support at the school level, support that can demonstrate, coach, observe and provide constructive feedback, facilitate networks of learners, and so on (Huberman, 1995; Warren-Little, 1993; Joyce and Showers, 1996).

PE: At least, we seem to agree that support is of the utmost importance. Huberman highlights the need to provide this support for teachers and a period of time to allow for development of ideas when he states that:

> "[N]either clarity of practical understanding nor appreciation of the significance of an innovation fully develops until teachers have gained some experience in trying it out in their own classrooms. Effective change has to include a period of development through use and research suggests that inset support should be linked to formative evaluation, mutual sharing of experience, and making of consequent adjustments to

plans and activities. Most of the support offered to individual teachers has to come from within the school itself. (Huberman, 1995, p. 249)

TE: But I think that the within-school support Huberman suggests falls far short of what is necessary to initiate true and lasting change in teachers' beliefs about learning and their actual classroom practice. While I agree that support needs to be provided at school level, I am not convinced that "most of the support" has to come from within the school itself. I do acknowledge that some strong support must come from within the school. Support from another teacher "buddy" or partner within the school, coupled with the principal's support, would be perhaps the minimum that could be expected. However, I would contend that this within-school support, is not in itself sufficient to sustain teachers' becoming self-determined learners but would require the ongoing continued support from a larger, more inclusive community that subscribes to developing a culture of learning to learn.

This community of learners would have a wider membership than just teachers acknowledging that "schooling does not exist and function in a vacuum but is connected to larger social forces" (Sugrue et al, 2000 p.27). This supportive community would offer a diversity of perspectives promoting a continual questioning and challenging of beliefs to encourage a constant reappraisal of "meaning perspectives" and a questioning of the assumptions that underlie policy initiatives. This supportive community cannot be assumed to exist and must be carefully and systematically cultivated (p.240). It requires an investment in personnel and the development of a framework of supportive structures in response to the needs of the community. In addition to this ongoing collegial support, we also need to acknowledge the necessity of supplying meaningful time for teachers to engage in the work of learning (Raywid, 1993).

CS: I have heard both your individual perspectives on teacher professional development but I can't quite decipher the key principles you see as important. I need to have an overview in order to understand or appreciate the complexities you believe are embedded in designing a professional development programme for teachers. If I had a framework, I could begin to build a picture of what you propose really could look like.

Personally, as I said earlier, I have difficulty understanding why teachers cannot integrate the use of the technology into their classroom practice once they have received the appropriate "skills training". I am not expecting everyone to do the same thing. In fact, I would expect that individual teachers would interpret the technologies as they see fit for their unique set of circumstances. What I can't understand is how you both believe that using these technologies in classrooms is such a complex process for teachers. Can you point to any readings or examples that would illuminate for me the type of supportive professional development environment you are endorsing?

TE: I'm thinking of a particular article by Warren-Little which I think will be helpful. Perhaps this is an opportune time to break for lunch and when we return, I will have located the reading I want to show you.

*During the recess for lunch TE locates the article and when they reconvene they begin the afternoon discussions with this article as the focus.*

TE: Warren-Little's statement documenting principles instrumental in appreciating the need for teacher support, and the issues to consider when trying to build a supportive environment, is particularly powerful. She identifies key points necessary for teacher professional development that are consistent with the ideas about learning as a social participatory process we discussed earlier. I have summarised and highlighted for you in italics the core ideas from this article, which we can discuss, point by point if it helps (Warren-Little, 1993, pp. 138-139, italics added).

1. Professional development should offer *meaningful intellectual, social, and emotional engagement with ideas, with materials, and colleagues both in and out of teaching*. This would be an alternative to the shallow, fragmented content and the passive teacher roles observable in much implementation training.
2. Professional development should *take explicit account of the contexts of teaching and the experiences of teachers, affording them a means of locating new ideas in relation to their individual and institutional histories, practices and circumstances*. This principle thus challenges the context-independent or 'one size fits all' mode of formal staff development that introduces largely standardized content to individuals whose teaching experience, expertise and settings vary widely.
3. Professional development offers *support for informed dissent* as consensus may prove to be an overstated virtue.
4. Professional development should be *grounded in a big-picture perspective on the purposes and practices of schooling*, providing teachers a means of seeing and acting upon the connections among students' experiences, teachers' classroom practice, and school wide structures and cultures.
5. Professional development prepares teachers to employ the techniques and perspectives of inquiry. This principle anticipates a model based more persuasively on the *pursuit of knowledge*. It provides the possibility for teachers and others *to interrogate their individual beliefs and institutional patterns of practice.*
6. The governance of professional development ensures bureaucratic restraint and a *balance between the interests of individuals and the interests of institutions.*

CS: Each of these principles is laudable, but they all seem very idealised to me. Utopian, even. Can you "put flesh on the bones", and indicate what some of these principles mean in the real world of schools. Take the first principle, for instance, relating to meaningful intellectual, social and emotional engagement with ideas, with materials, and with colleagues both in and out of teaching.

TE: I know that this statement is densely packed with many ideas that need to be expanded. To begin with, the Habermasian principle of the lifeworld rather than the systemsworld being the generative force is very evident as the emphasis is on "meaningful engagement". For the engagement to be meaningful, it needs to be personally relevant to the learner's needs and interests, so the learner is not detached from the process but is engaged intellectually, socially and emotionally. This principle reflects the fact that professional development is a complex, multi-faceted process and not just skills training. So professional development is not decontextualised; instead it is closely connected to social groupings and materials used, reminding us of the reciprocal relationship that exists between culture and the tools used by society.

This principle implies professional development as a social participatory process in keeping with the ideals of the situated and distributed learning theories. It emphasises the need for as wide a social group as possible, including people both in and out of teaching. This built-in diversity will help prevent the onset of myopia or the inescapable practice of navel-gazing I mentioned earlier, which is so often associated with very homogeneous groupings. Having a diverse grouping stimulates constant questioning and encourages what the third point refers to as informed dissent. This ethos of questioning empowers individuals then to interrogate their individual beliefs and institutional patterns of practice.

PE: To enable this type of professional development for teachers we would need structures to facilitate the engagement of socially diverse individuals. What would we have to do to accomplish this?

TE: When Senge (quoted in O'Neill, 1995) was asked what he would do first when trying to develop a learning community, he said his first step would be to find a group of people who were interested in doing things differently, or people at least willing to take a chance and make that leap of faith together. Next, it is paramount that the membership of this learning community be as diverse as possible as the learning community is exemplified when people from multiple constituencies at all levels collaboratively and continually work together (Louis & Kruse, 1995). This diversity across a community also contributes to "enhancing their capacity to create things they really want to create" (Senge quoted in O'Neill, 1995, p.20). So it would be important to include researchers, academics and practitioners in this new group developed to support teacher learning, in order "to move beyond a balkanised system the fault-lines of which appear to exist around theory and practice, to a more learning- and learner-centred approach where all contribute" (Sugrue et al., 2001,p.37).

PE: So what you are suggesting, then, is some form of partnership between schools and universities? You are aware that this sort of partnership has been tried in the past. Throughout the US, for example, school-university partnerships were established in an effort to address reform of both teacher and student education (Christensen et al 1996; National Commission on Teaching and America's Future 1996). Goodlad (1998) proposed that universities and schools work together in collaborative partnerships to develop the capacity for innovation and to create better learning environments for students. Such collaboration was expected to provide a practical basis for undergraduate education courses and anchor them in the reality of the classroom, as well as introduce the student teachers to exploration of their own learning.

This approach also would be "a means of healing the institutional rift between theory and practice and to give some practical substance to a Constructivist approach to initial teacher education," bringing "the practical expertise of teachers into productive tension with the research-based perspectives of academic staff" (Sugrue et al., 2001, p.35). Darling-Hammond and McLaughlin have demonstrated in several sites that when school/university collaborations: "emerge as true partnerships, they can create new, more powerful kinds of knowledge about teaching and schooling, as the 'rub between theory and practice' produces more practical, contexualised theory and more theoretically grounded, broadly informed practice" (1995, p. 601). Possibly one of the greatest strengths of partnerships is that they value "both context-specific knowledge and generalized knowledge and are structurally and philosophically more movement-like than organization-like" (Lieberman and Grolnick, 1996, p. 45). So such a network shouldn't suffer from the same sense of inertia that impedes large organisations, or be seen by participants as serving the strait jacketed agendas of the establishment, or be bounded by strict subject boundaries.

If we intend to recommend setting up networks of schools and universities, I suggest we pay particular attention to Parker's early work (1977, quoted in Lieberman and Grolnick, 1996, p. 8) that identified five key ingredients of successful networks:

1. A strong sense of commitment to an innovation
2. A sense of shared purpose
3. A mixture of information-sharing and psychological support.
4. An effective facilitator
5. Voluntary participation and equal treatment.

These factors are important to the design of a supportive framework meant to encourage the development of teacher learning.

TE: Let's extend our recommendations beyond the development of a network. Previous attempts at extending the membership of professional communities beyond classrooms and school campuses have demonstrated that this could be a powerful form of teacher learning (Darling-Hammond & Mc Laughlin, 1995; Wood 1995). These communities engaged individuals in collective work and brought them into contact with other people and possibilities, thereby providing opportunities for teachers to reflect critically on their practice. However, it has been found that that replicating or extending such initiatives is particularly problematic. Networks "have tended to evolve around particular issues and personalities and their 'founders' or 'facilitators' often feel particularly attached to 'their' group or issue so that extending or mainstreaming such initiatives may sound their death knell" (Sugrue et al., 2001,p.38).

A community, on the other hand, has much more fundamental requirements than a mere coming together of a group of individuals. To be a member of a community involves personal commitment and involvement – even passion on occasion. A commitment to enter into partnership with schools is not to be undertaken lightly, as embarking on the development of a worthwhile collaborative partnership would take a great deal of commitment and time. Teacher learning requires time and commitment if substantial changes in practice, rather than merely cosmetic ones, are to occur (Eraut, 1994; Guskey and Huberman, 1995).

The rationale for developing such a community is that it can support and sustain teacher learning (McLaughlin and Talbert, 1999; Cochran-Smith and Lytle, 1999, Nelson and Hammerman, 1996). Ironically, though, "despite lip service to lifelong teacher learning, the organisational, vocational, and cultural norms in ... schools conspire to create a situation in which community for teacher learning is found (if found at all) outside the workplace" (Grossman and Wineburg, 2001, p. 10). To develop teacher learning, we would have to prioritise organisational and supportive structures. For example, officially sanctioned release time for teachers would be a necessity if we mean to develop a community that would otherwise be seriously compromised by geographical location. Otherwise, meeting times after school hours could only be possible if teachers in a particular limited radius were willing to come together.

The community also should "support conversational and collaborative learning ...give sufficient feedback and be able to adapt to the needs of various learners" (Ruokamo-Sari & Pohjolainen, 1997, p.82). Increasingly, some researchers suspect that learning communities have the "potential to subject members to 'group think' and be coercive rather than liberating and empowering" (Sugrue et al., 2001, p. 39). So the development of an open, respectful ethos across the members of a community is vitally important to combat the "interactional congeniality" and "surface friendliness" that avoids intruding into individual's personal beliefs or practice (Grossman and Wineburg, 2001). In the initial stages of building a community conducive to teacher learning, we would have to work hard at building trust and honesty, as well as developing an ethos of acceptance and respect for difference while feeling safe to challenge and question.

CS: I agree with much of what you have outlined, even if it sounds a little Utopian. But what is the difference between other learning communities and what you are proposing?

TE: Gary Sykes argues that "an invaluable resource for teachers is a professional community that can serve as a source of insight and wisdom about problems of practice" (Gary Sykes, 1996, p.466). To date, though, the focus of these professional communities has been very firmly rooted in practice with an undeviating focus on student learning (Louis & Krase, 1995). In contrast, I believe we should concentrate on building a community of learners with the focus not just on student learning but on everyone's learning, particularly the teachers within the community.

We should build in critical questioning and exploration of what learning is about and how knowledge is created, in order to get under issues of practice and dig deeper to question the foundation on which this practice is based. If sufficient time and the appropriate supportive environments are cultivated, teachers could construct their own understandings of what it is to learn and how learning environments can be developed.

But we must openly acknowledge that taking action involves risk taking and teachers cannot be expected to go it alone. As we have discussed, the literature around teacher development and change clearly demonstrates that ongoing collegial support is necessary to meaningful and long lasting teacher change (Showers & Joyce, 1996; Darling-Hammond, 1996; Caccia, 1996; Raywid, 1993; Ruiz et al., 1995), particularly so when coupled with opportunities for reflective thinking (Darling-Hammond 1996; Hamilton & Richardson 1995). Rosenholtz (1989) maintained that teachers who felt supported in their own ongoing learning and classroom practice were more committed and effective than those who felt isolated and without support.

A range of studies (Zetlin et. al. 1998; Mc Laughlin and Talbert, 1993) demonstrated that a supportive community that encourages sharing and dialogue promotes both trust and the risk-taking necessary for the struggle entailed in transforming practice. Time to engage in such observation, analysis and reflection was also an important factor, as large-scale studies have found that changes in teachers' belief systems occur when they can attribute growth in students' learning to changes in their classroom practices (Guskey, 1986). In short, teacher learners must feel safe and supported, and they must be given time, in an environment that is flexible and understanding of different perspectives and learning styles, in order to develop their own "meaning perspectives" (Cranton, 1996) and become self-determined learners.

However, as previously indicated, teachers may find this personally threatening. They generally have been the "successful products" of a "transmission model" of schooling, and they will tend to perpetuate what has already worked for them, unless they are challenged by a serious and worthwhile alternative to their understandings of what learning environments can be. In the spirit of the Constructionist philosophy, how can one hope to build an environment that encourages Constructionist learning if one has never had experience of it nor had an opportunity to construct one's own understandings and knowledge of what learning is?

PE: Do you mean Constructivist rather than Constructionist?

TE: No, I'm referring to a development of Constructivism proposed by Papert (1986) with his theory of Constructionism.

CS: I'm confused. I am just coming to terms with what "Constructivism" means, as I've come across it frequently when reading about learning theory, the more recent teacher professional development documentation, and the latest curriculum policy documents. But I've never heard of "Constructionism". Can you explain the difference between "Constructivism" and "Constructionism"?

TE: For me, Papert's words encapsulate the difference between these two theories.

> the N word as opposed to the V word – shares constructivism's connotation of learning as 'building knowledge structures' ...It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in the construction of a public entity whether it's a sand castle on the beach or a theory of the universe (1991, p. 1)

CS: Can you explain this a little more, and perhaps indicate where you see the connection between Constructionism, teacher learning and the use of digital technologies? While I find these new ideas very stimulating, I am always aware that we need to ground them in the reality of policy-development recommendations for the use of digital technologies within our schools.

TE: Constructionism is based on two different senses of "construction." It is grounded in the idea that people learn by actively constructing new knowledge, rather than having information "poured" into their heads.

Moreover, Constructionism asserts that people learn with particular effectiveness when they are engaged in constructing personally meaningful artefacts. In the current digitised society, these artefacts can include designing and building computer programs, animations, or robots. These artefacts are "objects to think with" and a means by which others can become involved in the thinking process. Adopting this Constructionist approach to teacher learning, I believe, could help us answer this question: "What necessary steps must we take in order to enable teachers to become self-determined learners, and to develop a critical awareness of what being digital in learning means?"

We cannot continue to sidestep this question, for as Barbara Means (Milken, 1999) strongly points out the "Pandora's box of [digital] technology has been opened. We cannot close it again and make our society or our schools the same as they were before" (Milken, 1999, p.12). But the question is hard to answer because "to envision a system of education enriched by technology is an act of bravery. It requires the boldness, ingenuity and lack of nostalgia that every exploration of the unknown demands" (p. 10)

I believe that with sufficient time and appropriate supportive environments teachers can move beyond "first impact". They can construct their own understandings of what it is to learn and how learning environments can be developed using expressive computational materials. Teachers can use their own teaching practices as objects-to-think-with (in the Constructionist, Papertian sense), thereby externalising and examining their understandings of learning. Then they can experiment with and ultimately transform their teaching practices, their relationships with their students, and their understandings of their role as teachers. As learners, they will be actively involved in the learning process. So their experiences will be "meaningful" to them and their motivation levels will rise accordingly (Ruopp, 1993; Thompson et al, 1992, pp.11, 68; Thornburg, 1994, pp.24-25). Having the support of a community could prove to be a very powerful learning environment as other people are the greatest source of alternative views needed to stimulate new learning (von Glasersfeld, 1989).

I know that the development of a community is not a new idea. However, while many educational reforms revolve around the question of what is taught and how it is to be taught I would like to draw attention to why we teach what we teach. I think we should focus on changing the nature of the questions we currently ask about digital technologies and learning in schools, about how teachers are prepared to use these technologies and how the role of the teacher is perceived.

I recommend that we look beyond how teachers engage themselves with technology to how teachers' use of technology as they work alongside with their students allows them to redefine learning itself. Exploring the use of expressive digital technologies within a supportive learning environment, I believe, "makes it increasingly possible for ...[learners]...to engage in learning practices that lead to new ways of thinking, understanding, constructing knowledge and communicating results" (Milken, 1999, p.29). This learning community would concentrate on far more than merely improving teaching practices in order to improve student achievement. It would start to question what learning is really all about. Within this community, teachers' deepest beliefs about learning could be openly discovered and examined, with everyone getting to know themselves and each other as learners, and beginning to think about thinking. It could be a community "where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspirations are set free and where people are continually learning how to learn together?" (Senge, 1990, p.3)

The traditional pattern that "teachers teach, students learn and administrators manage [would be] completely altered". There would no longer be "a hierarchy of who knows more than someone else but rather the need for everyone to contribute". Everyone would be learners "questioning, investigating and seeking solutions" (Kleine-Kracht ,1993, p.393). As Hord commented "tradition and 'the way we do it' here" is challenged and discussed as a means to new insights and practices" (Hord, 1997, p.37). "The idea here is to build a culture that helps people to [construct] new knowledge that can make a difference" (Hord, 1997 p.44). I deliberately have substituted the word "construct" instead of the original word "gain" as I believe if you are really in control of your own learning you cannot 'gain' new learning as if it were something you could pass on to someone else: you have to become part of the active process, and build your own understandings.

In a nutshell, I am suggesting that immersion in a supportive Constructionist learning environment rich in computationally expressive materials can challenge teachers to question assumptions and beliefs about their own and others' learning, empowering them to become self-determined learners with a critical awareness of what being digital in learning can mean.

CS: While I applaud your conviction, do you have any examples or evidence that such an approach can work? Otherwise we can be accused of having our heads in the clouds, and guilty of recommending policy changes that "lack descriptions of restructuring initiatives that supply a detailed portrait of the learning demands on teachers and the corresponding professional development responses" (Warren Little 1993, p. 6).

TE: The "Empowering Minds" community is I believe an example that this approach can work. I also believe that the development of the EM community could go some way to rectifying this dearth of documented evidence of what teacher learning can be, within a community who engaged in "computer criticism" in order to "understand, to explicate, to place in perspective" the dialogue of digital technologies and learning (Papert, Nov. 1990, p.3).

PE: Is this a recently formed community? Is there any easily accessible documentation on it? We need a clearer understanding of what you propose we depend on to inform our policy recommendations.

TE: The Empowering Minds community developed from one of the first projects funded under the SIP initiative in 1998. Today, it is still a vibrant expanding community, with connections to several other learning initiatives that have developed as a result of its activities. I can compile a dossier of materials and documentations relating to this community and its developments and send it to you both before we convene for our next meeting.

PE: That sounds interesting, I look forward to finding out more about this learning community which teachers form a central part of.

CS: Yes, I'll be glad to have the documentation too, as it may help me understand some of the ideas you talked about this afternoon. I must admit, I still find many of them difficult to comprehend. Before we start talking, I had perhaps a simplistic understanding of how digital technologies should be introduced into classrooms. Now, I am beginning to appreciate how necessary it is that we acknowledge the complex interaction and influence of different epistemological, philosophical and psychological perspectives in developing our policy recommendations.

# Chapter Three
# ENVISIONING POWERFUL LEARNING ENVIRONMENTS

As the literature makes apparent teacher development programmes are generally fragmented and often lack a coherent focus (Irish White Paper, 1995). Many are also provider driven and bear no relationship to the actual contexts teachers subsequently are expected to create. Typically, teachers read about Constructivist learning environments (e.g., Primary School curriculum, DES 1999), but are never given the opportunity to be immersed in such contexts. Rarely are teachers' assumptions and beliefs about learning identified, confronted and challenged; they never are personally involved because they generally are not encouraged or allowed to set their own goals or decide how those goals should be pursued. As the teachers have not set their own learning goals they can hardly be expected to accept responsibility for the development programmes nor can they be held accountable for the outcomes. If teachers aren't engaged as the key players in the system, it is hardly surprising that so many programmes aimed at initiating a change in the system fail.

As a teacher with nearly twenty years of working with children and teachers in different contexts, I have a deep personal interest and investment in understanding what is necessary to empower teacher learning. Currently, I work in a large education department that prepares almost half of Ireland's primary school teachers annually. I am charged with designing a programme to help these pre-service teachers to use digital technologies in their teaching. This responsibility presented me with the challenging opportunity to think about what being digital can mean in learning and to reconceptualise how teachers can be prepared to work in these new learning environments.

I found a number of constraining factors to development, including existing college academic and administrative structures, lack of infrastructure, and faculty's generally very limited awareness or use of digital technologies. The "add-on and integrate technology" mindset was endemic. Management believed that there would be a need for some new courses teaching the "required ICT skills" but over time, these would be integrated into other established curriculum courses. I was concerned about this limiting mindset, as I was committed to a vision of teachers as learners, and of digital technologies as catalysts for changing how we think about learning and teaching.

I realised that, in tandem with building the infrastructure and "raising consciousness" within the college, it was critical to ground my vision in classroom realities. It was imperative, therefore, to develop a culture of learning rich in computational materials, with a community of learners across a geographical variety of school settings. Pre-service students and faculty could then become part of this learning community, while simultaneously grounding their own thinking about what being digital means in learning. The challenge to develop and facilitate this "thinking and learning" culture among practising teachers within the community of the Empowering Minds project is the focus of this dissertation.

The Empowering Minds project envisions a learning environment where teachers are not only viewed as facilitators of learning and as co-learners with their students, but are also accepted and respected as learners themselves. Learners who become self-directed, understand how they themselves learn so they accept responsibility for their own learning paths. To this end, rather than being talked at or exposed to learning philosophies or theories, teachers need to be immersed in a supportive learning environment that promotes and encourages each individual to learn about learning. At the centre of the process is the learner; that learner's experiences, needs and interests inform the learning process. A critical factor in developing this culture of thinking and learning would be the exploration and innovative use of digital technologies informed by a Constructionist philosophy. I had to consider carefully (a) the choice of computational materials to act as catalysts for thinking about learning; (b) the design of this learning environment, as an effective technologically rich support structure to facilitate reflection, technological fluency, and collaboration, in order to inform the design of effective and meaningful learning environments; and (c) the methods used to document aspects of this evolving dynamic process and provide richly textured concrete examples of Constructionism in practice (i.e., to describe the teachers' reactions to this learning environment, their learning styles, their engagement in systematic thinking and observations about their own learning and the learning that surrounds them in their classrooms and how they appropriated and used the computational materials)

This chapter describes the search for expressive computational materials, the challenge of designing and creating an immersive learning environment for teachers and the development of self-determined learners as the framework for sustainability. I describe the methods I used to document this process and emergent model of teacher learning in the next chapter.

## Designing an Immersive Learning Environment

In his doctoral dissertation, David Cavallo articulates the fundamental problems in existing teacher "training" programmes when he describes a shortfall in "Operation Lighthouse" in Thailand. Despite advocating strongly that teachers "needed the opportunity, time and access to people and resources in order to develop their own fluency with the new methodologies for learning and new technologies", he explains "for the most part too many of the teachers were not allowed adequate time to learn, to develop their own projects, to discuss ideas with their colleagues and others" (Cavallo 2000, p.223). Cavallo warns that this short-sighted view is often taken by administrators who "do not want to allow such development believing it is too costly" (Cavallo, 2000, p.253). However, he argues that while it

> certainly is a cost to free teachers for such an amount of time, there is a much greater long-term cost because teachers are often afraid to go into domains they do not know well and work with materials with which they are not comfortable. This later impedes the learners and design and development of the learning environments. The social, educational and arguably the economic costs of this in the long-term far outweigh the initial developmental costs" (Cavallo 2000, p.223).

I considered this observation by Cavallo to be of paramount importance. With the support of St. Patrick's College, MIT Media Lab and MLE, I made every effort to ensure that the time and adequate funding required for the development of the Empowering Minds project (http://empowering minds.mle.ie) was secured.

Funding for the first phase (March 1999 – June 2000) was provided by National Centre for Technology in Education's (NCTE, www.ncte.ie) School Integration Project (SIP) initiative (www.sip.ie) and *eircom*, the privatised Irish telecommunications company, under a special grants program that specifically encouraged collaborations between Irish schools, universities, and industry. Funding for second year of the project (August 2000 – June 2001) was provided under the NCTE's SIP initiative and the Higher Education Authority's (HEA, www.hea.ie) Multimedia Research Programme (MMRP 2000) fund for collaborative research between Irish universities and Media Lab Europe. The SIP initiative ceased funding for all projects in August 2001, but fortunately, the Empowering Minds project continued to receive funding from the HEA under the MMRP initiative from August 2001 until December 2003.

Key values that emerged for the development of this powerful learning environment, and that were concerned with changing teacher perception and practice of learning in a real school situation include:

- *Immersion* (as opposed to 'exposure'): Teachers would be immersed in an Atelier style learning environment with a set of rich computationally expressive materials that motivated, challenged and empowered teachers 'to learn about learning';
- *Sustainability*: Teachers were to be supported as they appropriated the computational materials in personally meaningful ways and began thinking about thinking. A range of supportive measures were needed, to ensure that once the process of thinking about thinking was initiated, it could continue and empower the teachers to become increasingly self-determined learners; and
- *Scalability*: Because good ideas can disappear so easily, we had to find a way to encourage, support and promote the 'viral' spread of ideas throughout an inevitably widening community of learners

Immersion and sustainability are inextricably linked: For learning to be really engaging it has to be an immersive experience, and for that experience to reach a significant depth of understanding, it requires sustainability to develop over time.

Societal pressure to become "computer literate" would be the hook to draw teachers into this immersive environment. I believed that engagement with the computational rich materials in the Atelier style learning environment would pose a challenge to the teachers' learning beliefs and assumptions. But the teachers' own needs, interests and experiences would provide a sustainable framework by informing the focus and direction of the ongoing learning process.

## Beginnings

With the values outlined above in mind from the outset, as well as findings from the research literature and personal experience, I made certain decisions about the design of the Empowering Minds project. To ensure that the teacher was at the centre of the learning process we included only teachers who indicated individual interest rather than going for whole-school participation. However, at least two teachers from each school were to be included as ongoing collegial support, as this was a key factor highlighted by other studies as a necessary component to meaningful and long lasting teacher change. The initial group was to be small (less that 10 teachers) to allow for the development of strong personal connections and meaningful engagement with learning about learning.

However it was important that the group should be typical of the general teaching body while also being as diverse as possible with a wide range of perspectives and experiences. With these goals in mind, we used these specific criteria to choose our Empowering Minds teachers: gender balance between male and female; a range of teaching experience; various ages; diverse geographical areas and school types; and varying levels of digital technology use, ranging from no experience at all to a very comfortable level of usage.

The literature suggests that the groups we belong to, and the materials or artefacts of the culture that we access, influence our cognition. If we are in agreement with this claim, it is imperative that the groups be richly diverse and that the range of accessible materials or artefacts is challenging to all levels of experience. The community's membership had to widen beyond teachers in order to provide different perspectives and challenges to how teachers understood the world. So the EM group actively sought a variety of resources and opportunities to engage with individuals having a range of expertise outside of teaching (e.g., film-makers, engineers, programmers, computer scientists). This professional diversity was particularly important, as teachers generally are the successful products of the established system, which has deeply influenced their understanding of learning and their willingness to engage with what does not fit this perspective.

To ensure that all teachers and children had the optimum opportunity to engage in personally meaningful, sustained, in-depth learning, we needed adequate supplies of hardware and expressive computational materials for each classroom. Other researchers have highlighted lack of sufficient equipment as a potential barrier to teachers' effective use and integration of digital technology into their practice. But time mattered most. We had to provide teachers with adequate time to engage with the process of "learning about learning" and to develop technological fluency.

We knew that if we satisfied these conditions we would have as diverse a group as possible, with varying experiences representing a wide variety of teaching perspectives from Irish classrooms. In order to bring such a diverse group together for an adequate period of time, with access to sufficient computational materials to engage critically in the enterprise of understanding the potential of digital learning we had to make a serious commitment to funding.

The Empowering Minds project was initiated in October 1998 by a proposal Fred Martin and I submitted to the NCTE, under the SIP initiative. Fred Martin was at MIT's Media Lab at this time and had been part of Papert's team, that developed the "programmable LEGO brick— a hand-held LEGO box that contained an entire computer capable of running Logo" (Martin 1994, p.50).

All Irish schools were invited to respond to the SIP initiative in October 1998. The nine teachers from four schools selected for the first phase of the EM project (March 1999 to June 2000) came from the main school-types prevailing in Ireland (large middle class suburban; inner city disadvantaged; medium semi-rural; two teacher rural). In an effort to have as many different school contexts as possible included within the EM community, targeted expansion for the second year (August 2000 to June 2001) included some single sex schools as well as children with special needs. Conscious also, of public concerns about the widening of the digital divide we included some more small rural and disadvantaged schools There are now 13 schools and 29 teachers participating in the project (See Appendix A for a full listing of schools and teachers). All the teachers volunteered to participate in the project, and they ranged in experience level from complete beginner to experienced user of digital technologies. The EM project achieved gender balance among the teachers, 14 males and 15 females ranging from early 20s to late 50s. There was also a wide diversity of teaching experience, from newly qualified teachers to near retirement across a range of different school contexts.

## *The Choice of Computational Materials*

Because they were expected to ensure that their students became technologically literate, teachers urgently needed to become familiar with digitial technologies. However, initially many teachers focused predominantly on making the technology fit the curriculum already in place. They tended to use content software specially designed around a particular topic, or used the application packages to do what has traditionally been done with paper and pencil. Although teachers could ask children to search the web for resources and use multimedia packages to put their findings together, and some of them did so, for the most part the traditional curriculum stayed firmly in place, so neither the classroom relationships nor the teacher's role changed. In fact the only difference was that a different set of tools was being used for the same purposes and the type of learning that occurred was still firmly controlled by the teacher. This is not surprising, as the training courses generally developed for teachers to come to terms with these new technologies were all skills-based and content driven. No real attention was paid to teachers' needs, interests or experiences as generic courses (e.g. NCTE's Level One and Level Two Courses) with a particular set of skills that were thought to be necessary for "computer literacy" were developed, to be delivered to all teachers, irrespective of individual contexts.

Some course providers made efforts to contextualise the content with exercises that had been given a school flavour e.g., draw up a timetable or a class list using the Tables function in a word processor; design a poster for a school concert; using Excel to draw graphs required for the mathematics programme. Extant curriculum dictated the vision. These technology courses were, and continue to be, predesigned and packaged in units, with tutors trained to deliver them to large numbers of teachers. They are designed purportedly to teach teachers to integrate the technology into the existing curriculum, but not to challenge or question the structure of knowledge or the nature of knowing within the educational system. These courses maintain the 'status quo' and treat teachers exclusively as consumers of knowledge.

### *The Search for Expressive Computational Materials?*

The materials and the context in which they are used not only determine our way of thinking about the world, but they also bound the range and breadth of thinking that is possible. I wanted to avoid this narrow approach to learning by using digital tools that could be easily grafted onto existing content and methodology. So I searched for technologies capable of opening up the possibility of approaching learning in a new way. This creative learning would enable learners to work alone and/or together on a substantial problem that would be relevant and meaningful to them. In addition, in order to challenge teachers' beliefs and assumptions about teaching and learning, I proposed to use these computational materials in a context dramatically different from the typical teacher professional development programmes.

These computational materials would have to be versatile and capable of multiple interpretations and uses; they would have to enable the user to become a designer and really enter their world acting and thinking like a designer. Rather than hearing about what it is to design, the learner using these computational materials would be engaged in designing. While immersed in the act of designing, learners could learn to express what is important to them and to the problem they are trying to solve. Engaged in this way they could learn how to design through the act of designing: they could learn to think by thinking about thinking. In an immersive environment the versatility and expressiveness of the materials would mean learners had the freedom to determine and pursue their own questions, rather than an externally determined single right answer. The interactive nature of the materials themselves would open up significant possibilities for design rather than bound the realm of possibilities. Teachers working with materials in this way, could move away from the easily taught and evaluated methodologies that currently stifle creativity and innovation in our classrooms. Schon (1983) encapsulates this learner's negotiational learning process when he refers to the act of designing as having a "conversation with the materials of a situation".

> There are more variables—kinds of possible moves, norms, and interrelation-ships of these—than can be represented in a finite model. Because of this complexity, the designer's moves tend, happily or unhappily, to produce con-sequences other than those intended. When this happens, the designer may take account of the unintended changes he has made in the situation by forming new appreciations and understanding and making new moves. He shapes the situation in accordance with his initial appreciation of it, the situation "talks back," and he responds to the situation's back-talk (Schon, 1983, p.79).

The materials should invite contemplation and negotiation as the learner sets out to realise their goals "in a spirit of a collaborative venture" with the materials (Turkle & Papert, 1990, p.9). This type of relationship with the materials brings to mind the learning style of the *bricoleur* as described by Turkle and Papert:

> The bricoleur resembles the painter who stands back between brushstrokes, looks at the canvas, and only after this contemplation, decides what to do next. For planners, mistakes are missteps; for bricoleurs they are the essence of a navigation by mid-course corrections. (Turkle & Papert, 1990, p.9)

Educational institutions that emphasise and value the more structured approach that privileges hierarchy and abstraction over negotiation and construction have typically not valued the bricoleur type of learning. However, it must be recognised that bricolage is a way to organise work and is not a stage in a progression to what generally has been regarded as a superior form of thinking. Turkle and Papert have called for an "epistemological pluralism"—a recognition that the bricoleur's style is valued as a style in itself, and not just as a stage in an intellectual progression toward the "formal" planner approach (1990, p.12).

In common with the Logo programming environment I was searching for materials with characteristics that are commonly termed "low ceiling/ high threshold". These materials should be easy to begin working with, and enable the learner to construct something personally meaningful. Simultaneously these materials should have the capacity to grow with the learner, and to provide the stimulus and building components to construct more in-depth and probing projects.

In addition to being attractive and motivating, the materials would also have to be robust to survive daily handling by multiple users in a classroom setting. Such materials would be worth paying for. To summarise, the computational materials needed to be *conversational* accommodating feedback and negotiation; *connective,* enabling a learner's personal relationship/connection to powerful ideas; and *challenging*, leading to more than one "right" answer / more than one way. These qualities of the computational materials coupled with the Atelier style of working described in detail later in this chapter could provide the intense experience - the spark – towards building the immersive environment necessary to challenge teachers to question and begin to think about thinking.

My search for such technologies lead me to the MIT Media Lab in particular to the work of Seymour Papert. Mindful of Yeats' observation that, "Education is not the filling of a pail but the lighting of a fire", I believed that these computational materials and the Atelier style of learning informed by a Constructionist philosophy that encouraged an open, constructive, exploratory and playful approach to learning could ignite the fires of thinking about thinking.

In the course of my investigations, I met with Fred Martin one of the developers of the Programmable Brick, which was a derivative of the LEGO/Logo work done in the mid-1980's by Seymour Papert, Mitchel Resnick, Stephen Ocko, and Brian Silverman (Resnick &Ocko, 1991; Resnick, 1990). This work, in turn, evolved out of Papert's work on Logo, the children's programming language, which began in the 1960's (See Appendix B for historical development of these computational materials). The Constructionist philosophy and playful approach to learning has inspired each generation of development of technologies at the MIT Media Laboratory, and continues to do so as researchers strive to develop technologies that mine children's natural modes of thinking through exploration and play, rather than through abstract symbolic thought.

The commercially available LEGO Mindstorms product formed the core materials around which we developed the Empowering Minds project. This robotic construction kit, based on the Programmable Brick developed as a result of the research at the MIT Media Lab was launched by the LEGO Group in 1998. Empowering Minds shares the cross-curricular approach used in the Peace Dale Elementary School in Rhode Island (Martin 1996) in addition to the Bers and Urrea's (2000) focus on the narrative, story-telling ingredient of children's technology projects. The LEGO Mindstorms kit is packaged in several fashions, somewhat differently for the retail market and the scholastic market. In, all configurations, though, it consists of the following:

- The "RCX Brick," a programmable LEGO brick that contains a tiny computer, batteries, a display screen, and circuitry to operate motors and connect to sensors.
- Motors and various sensors, including touch sensors and light sensors
- A large collection of LEGO building blocks, including the traditional bricks, decorative pieces, and newer pieces like gears, beams, axles, and other mechanical components

The basic Mindstorms kits were augmented with other Lego materials, available from DACTA, the educational development branch of the LEGO company. This included a range of basic building blocks, extra gears and pulleys, plus "Yellow building kits" that explored the concepts of gearing, pulleys, wheels and axles, as well as teacher resource materials (See Appendix C for a full listing of materials supplied to schools).

Once I had found suitable computational materials, I then faced the challenge of introducing them, along with this learning philosophy, in Ireland. I was able to do so when the NCTE announced its SIP initiative. I developed a proposal for funding the Empowering Minds project, and it was accepted (October 1999 – January 2000).

### *Making it Conversational*

Constructing something with concrete materials has the advantage of "observability" (Martin 1994, p.101), in that learners can test whether their thinking works from what they see the artefact do. But with a lot of concrete materials (e.g., wood, paper, metal card), if you are making something, and it does not work, it is often difficult if not impossible to reuse the materials and test out another permutation of your idea because you may have been cut or shaped the materials in a particular way to serve the purpose of your first idea. Besides the expense of countless sets of fresh materials, it's not very motivating to have to begin from first principles, each time to model and shape your ideas.

But with the Lego Mindstorms materials it is easy to adjust the creation to begin all over again and use a different set of building components that, quickly and easily snap together. Working with highly observable materials in this way encourages an iterative process because learners actually see changes and can incorporate them into consecutive stages of their design process. Problems are easier to diagnose and "through natural interactions with the material, the user can readily determine the properties of artefacts that he or she has constructed with it." (Martin, 1994, p.101)

The Lego Mindstorms materials are particularly productive in this learning experience because they can offer valuable feedback to help the learner work out the next stage of the problem they are trying to solve. The learner is involved in a conversation with the materials. It is a two way process. Learners who are open to this interaction with the materials benefit in the construction of the artefact. Learners who are able to interpret a problem and are willing to change direction, redefine the problem or even begin again, have the keys not only to learn how to work with these materials, but also in learning about learning.

### *Making it Connective*

By "being connective", I mean that the materials enable the kind of engagement that lets the learner develop both a sense of personal relationship with the computational materials and a deep connection to powerful ideas. For some, the bright attractiveness of the materials had an almost hypnotic effect, and their fingers itched to put the pieces together to construct something of their own.

*Figure 1:* Members of the Danish Ministry. Caught in the act!

Even these Danish ministry officials, accompanying their Minister of Education on a visit to one of the EM project schools, couldn't resist investigating the children's models depicting the story of the changing inner city landscape around their school (See Figure 1 above).

The materials were open-ended and capable of diverse individual interpretation. Working from their own ideas, members of the group built amazingly imaginative and innovative structures - a pair of toucans, for instance, and Nellie the Elephant (Figures 2 and 3 below).

Some of the teachers in the group did complain that the pieces were hard with no rounded edges, had only one texture, and were available only in very definite bright colours, which they believed limited construction possibilities. However, many of the children found ingenious ways to get around these perceived drawbacks, and they continually surprised their teachers with their and creative workarounds.

*Figure 2:* Nellie the Elephant

*Figure 3:* Toucans

Especially ingenious in the face of a perceived problem was the eight year old with a deep interest in mythical creatures, who decided to build a magical creature, inspired by a Greek legend he had read. As it was a magical creature with very special powers he decided that it should be an unusual colour not normally associated with animals. He chose to build only with blue bricks his favourite colour so everyone could see how special his creature was. He ran into a problem right away though, because there were very few blue bricks available. Initially, he was somewhat disappointed, but after some thought, he quickly modified his original idea and made what he described was a better creature. It still had magical powers but only certain people knew, because the creature could be recognised only by its unique blue eyes.

This boy elaborated on the existing story and made it his own when he had to change his construction plan due to a shortage of the raw materials he initially wanted. What he might have perceived as a prohibitive problem, he successfully turned to his advantage: the shortage of particular materials had added to, rather than detracted from his learning possibilities.

*Figure 4:* Mexican God

*Figure 5:* The Dancer

*Figure 6:* Opening Flower

*Figure 7: Jewellery Box*

Teachers and students alike enjoyed personalising the materials. LEGO materials combine successfully with other materials, so we encouraged them all to use craft and junk materials in their models (See Figures 4 to 7 above ), and in the scenarios they constructed for the models to occupy (See Figures 8 to 11 bleow).

Learners could then use the LEGO materials for the things LEGO does best, like fast prototyping of ideas and the things that are difficult to do using other materials, for example, building a solid structure / framework, or incorporating moving components. When a range of craft materials was in plentiful supply, the teachers incorporated other materials with the LEGO building materials. And, when they returned to their classrooms, some of the teachers incorporated a range of other craft materials for the children to use in building their models.

*Figure 8: Dorothy on the Yellow Brick Road*

*Figure 9:* Drawing room at Castletown House

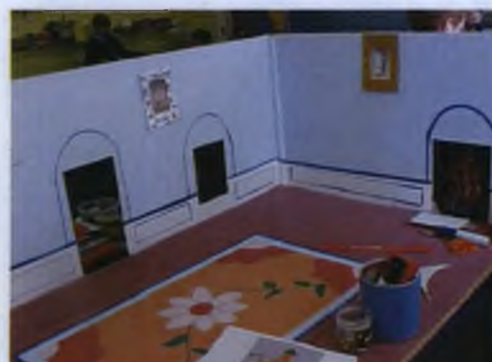


*Figure 10:* A Norman Motte and Bailey

*Figure 11:* The Iron Giant's junkyard

However the majority of them, were inclined to be over reliant on using the LEGO materials. Many of these teachers explained that they were trying to take care of the computational materials and to prevent them from getting mislaid, as they knew these materials were expensive and if lost, might not have been replaced. Some teachers also commented that when craft materials were used in conjunction with the LEGO materials, children could not bring their creations home because the LEGO materials had to remain at school. They preferred to devote their craft resources to constructing things that the children were able to bring home. The teachers valued the learning experiences possible with these materials and did not want to be in a position of not having them to work with. The majority of the teachers tended to use the LEGO materials to build the moving models and used an extensive range of craft materials to build the scenarios and environments in which these models existed.

Papert and Turkle claim that "the conventional route into formal systems, through the manipulation of abstract symbols, closes doors that the computer can open" (1990, p.18). In all classrooms, Empowering Minds saw prolific evidence of learners "dealing with the world of formal systems." Because they had access to expressive computational materials, children and teachers grappled with concepts and ideas, that would not otherwise have been possible. Across the project classrooms, countless examples illustrated that "the computer ...can make the abstract concrete; it can bring formality down-to-earth" (Papert & Turkle, 1990 p.2). These experiences were instrumental in sustaining teachers' interest in continuing to work with these materials. They also helped quell their nagging doubts that they were neglecting "the curriculum" because they were spending so much time working with these computational materials.

For example, normally children of about eleven years (5$^{th}$ class) in mainstream mathematics are exposed to concepts of ratio and the relationship between distance, speed and time. But because these ideas can quite often be presented in a disembodied context, children generally don't thoroughly engage with these concepts in any depth. Children then tend to memorise the rules of the required algorithm, but their understanding generally goes no deeper than superficial manipulation of abstract symbols. However at one of the group meetings, an Empowering Minds teacher described his experiences when three groups of children tried to build models that, would measure the entities they were studying:

- distance, by building a model that could calculate how far it travelled as speed and length of time were varied;
- speed, by building a model that could calculate how fast it travelled over a specified distance or for a specified time;
- time, by building a model that could calculate how long it took to travel over variable distances at variable speeds.

They worked on this task for several weeks, building various models and, with each iteration, coming closer to understanding the complex relationship between distance, speed and time. They could build, programme, trial and test each of their ideas in a concrete way, in order to examine whether the model was in fact measuring what it was intended to measure. The groups collaborated constantly; teachers and children tied themselves in countless knots trying to unravel the complex inter-relationships of these abstract notions of distance, speed and time. Such in-depth exploration confirmed for the teacher that this Constructionist way of working was especially powerful and meaningful, and could develop children's understandings of mathematical concepts and relationships in a way that would not have been possible without the computational materials they worked with.

This developed understanding was regularly witnessed when children tried to build models that required more torque and less speed, which confronted them with the ideas of gearing and gear ratio. For example, a six-year-old girl explained to her teacher that because the motors were working too fast, she had to slow down the woodcutter model she was building so he wouldn't knock down Red Riding Hood. When the teacher asked her to demonstrate what she meant the six-year-old showed her teacher the gearing mechanism she had constructed, while confidently telling her that:

> I used an eight-toothed gear on the motor to turn a twenty-four- toothed gear which would make the woodcutter go three times more slowly because the small gear would have to turn three times to make the big gear turn once. This would make the woodcutter go more slowly and he would be more powerful as well (Observation field notes, May 2001).

Not only could this young child explain ratio, but she also had a very clear understanding of the relationship between speed and torque. Here is a clear example of situated knowledge. This young girl had a clear understanding of quite complex concepts because she had come to understand them by developing her own projects using computationally powerful expressive materials in an environment that, encouraged exploration and reflection. If such understandings had been decontexualised, it is debatable whether this child would be able formally to represent the ratio of eight to 24, or be able to say that three multiplied by eight is equal to 24. What is important is that she has had experiences that have demonstrated she is capable of understanding complex ideas, and she is able to articulate her understandings. She is building conceptual understandings of powerful ideas that she can later represent in formal and abstract ways.

Besides manipulation of abstract symbols, building the models led the children and teachers to discussions confronting issues that they otherwise might never have conceived. In one classroom, when they were building models to represent human and animal forms and behaviours, some of the issues under discussion included:

- What behaviours of animals could we recreate in our models?
- What features and behaviours are essential to represent different creatures?
- If a horse had wheels, could it still be a horse?
- What would be the difference between the model of a cat and that of a horse?
- When trying to build a model, what is possible and what is not?
- When we decided that something was impossible, was that because the technology was limited, or because our knowledge of the technology was limited or because it was just too much trouble? (Observation field notes, November 2000)

In another classroom, children who were diagnosed as needing extra learning support used the Mindstorms materials, their digital camera, and the programming environment of Microworlds, to construct models and animations to tell stories that were important in their lives. For example, they explored issues relating to peer pressure and bullying (Observation field notes, April 2002). Using computational materials these children, who did not have an "acceptable proficiency level" in the traditionally highly valued skills of reading and writing, could nonetheless confront important issues in their own lives. They were able to articulate, express and make sense of these issues, which they were unable to do using traditional media.

As a result of their experiences back in their classrooms, teachers began to realise that once they opened up a world that, used a variety of computational materials for expression and meaning making, children who had been denied a voice, found new ways to make sense of the world by expressing themselves in imaginative and innovative ways. In addition, they were able to access ideas and concepts in concrete ways and gain complex understandings of issues that were not thought possible.

### *Making it Constructively Challenging*

When we combined the power of the LEGO materials with the Programmable Brick, the children and teachers could build structures that were not possible before. They designed and built their own models that incorporated motor control, sensor input and programming. The Programmable Brick allowed them to build "intelligent" models that could operate autonomously away from the computer. Because the data came from physical sensors and was used to control physical motors, the programming experience was more concrete and instinctive for them. Encouraged to take risks - not feeling restricted by 'a single right answer' mindset - learners set themselves challenging projects motivated by their own needs and interests. They encountered difficult problems, but having a concrete "object to think with" that they could use to demonstrate and engage other learners in dialogue about their problem, helped them debug while also making connections to some very powerful ideas.

These qualities of the materials contributed to the immersive nature of the learning environment, making it a more personally meaningful and relevant learning experience for the teachers and their students (A brief outline of common difficulties experienced when working with the computational materials appears in Appendix D).

### *Removing Barriers: Adequate and Appropriate Hardware*

Other researchers pointed out that access to adequate and appropriate hardware (e.g., computers and digital cameras) is crucial to teachers' effective use of and integration of technology into their practice; without enough of the right hardware they come up against real learning barriers. The Empowering Minds project team (myself, Fred Martin and the teachers) tried to minimise these barriers by listening and responding to the needs and interests of the teachers when deciding on what hardware to use in the project.

#### *Laptop or desktop?*

Rather than purchasing a particular computer and presenting it to the teachers we provided a grant they could use to buy the machine of their choice. In this way teachers felt ownership, as they could choose a machine that best fitted their needs. All but one of the teachers chose to have their schools augment the grant provided, in order to purchase laptop computers rather than desktop machines. The teacher who initially purchased a desktop computer bitterly regretted his decision. In addition to the flexibility of classroom organisation the other teachers talked about, he saw how convenient and efficient laptops were, particularly at exhibitions for the other teachers to reprogram models or share resources. By the beginning of the second year of the EM project, he had utilised his school's resources and other grant payments to purchase a laptop.

The choice of laptop rather than desktop computer has been significant in the teachers' development. For the teachers, the value of having the computer at home cannot be overemphasised; they loved being able to write up their journals, send email, find resources on the Internet, and programme the models on their own time, rather than having to stay at school after a tiring day. The complete beginners especially felt this way; they could try things out at their own pace, in their own time and without the pressure of time constraints and other people's eyes.

To Bernadette, a complete novice, the laptop became an integral part of her daily existence, to which she claims her family will testify, as for months she talked about nothing but her "wonderful laptop" that was helping her to learn so much. Because she was able to bring it home, she could call upon her two young sons, then aged 8 and 12 years respectively, to help her when she got into difficulties. Unrestricted by a school timetable, she once stayed up until 3a.m. because she was so immersed in solving problems that were important to her as she learned to program her model.

All of the teachers claim that if they hadn't been able to bring the computer home, to "tinker around and play with", they would not have achieved such computational fluency. Many of the teachers described instances when after a group meeting, for example, they continued thinking, mulling over ideas that had come up in the meeting. Then, although it was often quite late, they could try out whatever occurred to them as soon as they got home because they had own laptops. So the laptop, as opposed to a desktop model, contributed to the immersive nature of the project by extending the links between home and school. Conventional boundaries between home and professional lives blurred – naturally and productively – when technology became not just something the teachers used at school but became part of their daily lives beyond school.

Shane, a young male teacher in the group, often tells the story of a long planned get-together with a group of his friends that took an unexpected turn. They had all arranged to meet up at Shane's house before going out for the evening. Prior to their arrival, Shane was using his laptop to program a model he had been building, using the Mindstorms materials he had brought home from school for the weekend. As each person called, they were intrigued by what he was doing and began asking questions and tinkering with the materials. Shane was amazed because although there was a wide range of occupations among the group, including an engineer, an accountant and a mechanic, each of them seemed enthralled by what he was doing. Before long, an animated, lively building and programming session was in progress, with everyone participating enthusiastically, each contributing in different ways to what had now quite definitely become a group endeavour. They were so absorbed, they ended up ordering takeaway instead of going out as planned, and they all agreed they had a thoroughly wonderful evening. Before they left, a few of them even enquired where they could purchase the materials. This was the first time any of Shane's friends had shown genuine interest in or had meaningfully engaged with anything that he was doing in school. They all commented to him about how exciting it must be, working with these types of materials in school, and what great fun the children he was working with must be having, learning with these new computational materials.

The teachers still comment regularly about how glad they are that they chose laptops rather than desktop computers. They use their laptops so often now that they consider them part of the furniture that they cannot do without. They find the laptop is much more user friendly because they don't have to set up a special area for computer use. Teachers and children can bring their laptops along wherever they go, rather than having to go to a particular place to work on the computer. So the users decide how, where and when to use their computers, as the physical space is not an issue. The computer has become something they control and use whenever they choose, whenever the mood strikes them, rather than having to structure their schedules around the computer's location.

### *Digital camera*

A digital camera that recorded pictures on floppy disks (the Sony Mavica-MVC-FD73 and MVC-FD75) was provided for each school to help record the learning process and the projects the children created. The cameras we purchased were chosen because they were simple to use. This has paid enormous dividends as all teachers and children are using the cameras confidently and effectively on a daily basis. The digital camera was used to photograph models during construction and when they were completed. This helped ease the pain for the children when breaking up their creations in order to begin a new project. They did not mind dismantling their models once they had the photo of it. Each child generally had a folder on the laptop into which they filed their photos. These photos were a record of what they had made and were also used when writing up their 'learning stories'. Children often referred to the stored digital photographs when building other projects or describing for others how a model had been made and the problems they may have encountered. They took great pride in their constructions and wanted to share them at home. Having the camera meant they could bring their photographs home on disk if they had a computer or alternatively the images could be printed out. All teachers agreed that this was a very important link in developing home schools relationships. As one teacher wrote:

> Daniel asked for a printout of the photograph of his model to put on his bedroom wall. "My mammy will be amazed," he said. His mother subsequently came with him to the Education show in the RDS (Ursula, End of year project report, June 2001).

The use of the camera has been eagerly appropriated by the teachers and children as they use it for a myriad of purposes—e.g., school events (sporting occasions / concerts); recording other learning experiences (how a tree changes over time) or discoveries (comparison of insects); storytelling.

Above all the availability of the digital camera is instrumental in enabling a number of layers of reflection. Having the digital images enabled the children to reflect on their own learning process and their development over time. For the teacher these images were not only a vibrant library of the children's work but could help a teacher reflect on their students' learning and the teacher's own new emergent role in the learning process. Finally, for the researcher having access to a rich bank of digital images captured the learning process in action across a wide range of classrooms enabling reflection of the diversity of contexts contributing towards the development of an understanding of different teachers' "meaning perspectives".

The computational materials alone however would not challenge teachers to think about learning. Neither would the materials alone motivate them to question their existing beliefs and assumptions causing them to make changes in their classroom practices. An immersive learning environment that used these computational materials had to be designed in which this process of thinking about learning could be initiated.

## *The learning context - Atelier style workshops*

This learning process cannot take place in a vacuum nor can it only be a solitary exercise. The context for learning will have to be social and the creation of knowledge a participatory construction process. However, as there is an intimate connection between knowledge and activity, the type of activity teachers engage in is paramount. As teachers have been generally passive recipients of prior 'education' it is hardly surprising that they perpetuate the 'transmissive' model of learning. A strong 'consciousness raising' (Freire, 1972) process was necessary in order to awaken teachers' understandings of what learning could be and broaden their perspective on their practice. The importance of broadening and changing a teacher's meaning perspective cannot be overstated as this is the framework that shapes their perceptions of not only themselves but also of others and their surroundings. This perspective is formed by experience. Therefore it is critical if change is to occur that a teacher's experience must be continually broadened. In tandem with the breath of experience must come a constant need for questioning. A range of new and very different experiences were necessary if teachers were to begin examining their entrenched assumptions and beliefs about learning. Looking to the culture the teachers in this study were part of it became apparent that digital technologies could provide the focus necessary. My belief was if teachers engage in challenging learning experiences which help them understand their own learning this could empower them to develop alternative ways of structuring learning environments for their students because to "understand in a different way" increases potential for alternative actions (Gadamer 1975, p297; Dunne 1993; Grundy 1987).

Drawing on the literature from adult learning (Lindeman, 1926; Knowles 1998) we ensured that the teachers' own personal needs and interests coupled with their experiences formed the starting point around which to challenge and build new ideas and perspectives on learning. This valuing of the teachers' prior and ongoing experiences in the classrooms was of critical importance because this was what formed their understandings and beliefs about learning. If there was going to be any change in how these teachers viewed the learning process it was only going to be if they themselves constructed "their own understandings of their work and roles and adapt according to their beliefs and positions" (Cavallo 2000, p.225). An Atelier-style learning approach, underpinned by a constructionist epistemology, was the model used to design the learning environments experienced by the EM group.

### *Features of an Atelier style of learning*

> A primary goal of the Atelier/workshop is to bring together a community of learners ... At the Atelier event, they collaborate, communicate, learn, and reflect by being together. They combine the new concepts they have explored with their individual and collective knowledges, experiences, and stories; they weave a tapestry from the colorful threads of their diverse backgrounds and interests. They engage their collective creative potential and their understandings of their environment (Ueda, 1999).

The Atelier model is rooted in European traditions of artisanship. Many of the features of the Atelier design studio particularly popular in art and architectural design studios today have been modelled on the Atelier-based training at the Ecole des Beaux-Arts in 19th Century Paris (Chafee, 1977). "It is a way of working that emphasises experimental production: building, crafting and demonstrating become ways of situating ...inquiries" (MLE Brochure, January 2002).

The EM workshops (indeed the focus of the Empowering Minds project) were and continue to be people-centred ensuring all participants are treated in a caring and respectful way. Every effort is made to focus on each individual's needs and interests to support them in becoming self-determined learners. We do not impose decisions on the group or tell them what to do, the teachers make their own choices which we believe "works wonders in terms of creativity and morale" (Haase, 2000 p.428).

As in design studios for arts and architecture, during the teacher workshops the teachers work side by side with more experienced practitioners (e.g., the researcher, Fred Martin[2], Glorianna Davenport[3], John Bilotta[4]) who frame techniques and offer comments. They interacted with the teachers "extensively, answering their questions, helping them solve problems and otherwise listening to their thoughts and concerns...This style of interaction was more as between peers than as between teacher and student; often the problem puzzling the [learners] was one we had not yet solved ourselves" (Martin 1994, p.65). This way of working has also been transferred by the teachers to the classrooms and was initially heavily supported by classroom visits of the more experienced personnel (i.e., Fred Martin and Deirdre Butler) until the teachers and children became comfortable with the computational materials and this new way of working.

The Empowering Minds concept emerged through a series of workshops (See Appendix E), which enhanced the cultural connectivity between the teachers. The immersive Atelier workshop approach is a process common to other projects which Papert has been involved with including Project Highlight at Boston's Hennigan School during the mid-eighties (Harel and Papert,1991), the Omar Dengo Foundation's work in Costa Rica[5] and Project Lighthouse in Thailand (Cavallo, 2000). The Empowering

[2] Fred Martin, formerly of MIT's Media Lab now a computer science professor at UMASS, Lowell
[3] Glorianna Davenport, Principal Research Scientist at MIT's Media Lab and Media Lab Europe
[4] John Bilotta, now a school's technology advisor but formerly a teacher involved with the research of the precursor of the Lego Programmable Brick in Peace Dale Elementary School, Rhode Island.
[5] http://www.fod.ac.cr/

Minds methodology was to have these workshops and then extensively support the teachers with their own styles to bring the computational materials and learning approach into their classrooms.

The approach adopted in the workshops had many of the key features of an Atelier style of working as identified by Kuhn (2001, p.5) as:

- participants engaged with complex open-ended problems over a protracted length of time
- collaboration was encouraged
- reflection was explicitly incorporated
- a heterogeneity of issues were addressed.

Consistent with the Atelier approach, as projects are being developed there is constant ongoing discussion and critique of the work as ideas and constructions grow and change. A special strength of the Atelier style "is its ability to support multidisciplinary and integrative education. The studio can act as a forum for debate and discussion of a wide variety of issues" (Kuhn 2001, p.3). A predominant design feature of the teachers' workshops has been to use the active building sessions as opportunities for reflective discussions about the learning process – 'thinking about thinking'. Throughout the workshop teachers discussed a wide variety of issues ranging from how schools are structured for learning to the inadequacies of evaluation procedures for assessing this type of learning and the multidisciplinary nature of the projects developed. Great efforts are made to develop an atmosphere of trust and acceptance among the group so that people feel comfortable expressing their opinions and understand that dissension and disagreement are accepted. The computational materials and the Atelier-style learning approach "encourage dialogue, self-expression, community and reflection" (Ueda, 1999). People are learning through experience – learning by doing. Throughout the workshops and in the classrooms learners are reflecting on what they are doing and beginning the process of 'learning about learning'.

### *Structured, unstructured or self-structured?*

Normally, on teacher in-service courses or workshops, tasks and objectives are tightly prescribed with fixed criteria, which provide a comfort zone for the majority of teachers and removes from them the burden of accountability. Consequently as they are not responsible for the choice of task they are not accountable for the outcome. However if you choose the learning goal you wish to pursue you are accountable for what takes place, as you are responsible for structuring the learning experience. Informed by the constructionist theory (Papert, 1986, 1991) the Atelier style format of the EM workshops was what many, including the EM group teachers initially might term 'unstructured' in that the participants were free to use the computational materials to construct whatever they were interested in. The control and responsibility for what was to unfold in the workshop was in effect left to the participants to decide. Rather than being 'unstructured' it was in reality a 'self-structured' learning environment with the learner having the power to decide the workshop format rather than having a structure imposed upon them. Imposing no preset time limits or particular objectives that had to be achieved within a certain time frame was a special feature of the EM workshops. Using these computational materials members of the group began to realise that learning can take a long time as they struggled to understand and develop some solution to a particular problem that had occurred as a result of the goal they had set themselves. This was in stark contrast to the tightly timetabled 'inservice' sessions with neatly defined objectified behaviour they had become accustomed to. It was anticipated that the teachers might find this way of working threatening as the teachers were not used to being self-directed and determining their own learning goals. Consequently I tried to structure the first workshop in a way that would facilitate and encourage the teachers to begin the process of moving towards self-determination.

### *Structuring the workshop to encourage learners to take control*

Understanding that the teachers were not used to being self-directed and determining their own learning goals an open evening was organised several weeks before the first workshop with the teachers and school principals to discuss the computational materials and the proposed learning approach. The teachers were anxious about the unfamiliarity of the computational materials with some thinking that their lack of technical experience was going to be an insurmountable stumbling block. They were also a little unnerved about the open exploratory nature of the forthcoming workshop and myself and Fred Martin's admission that we would not have 'all the answers'. We would be 'learning together'. However they were encouraged that we were firmly committed to supporting them in whatever way possible. At this initial meeting and before the first workshop everyone was given the opportunity not to continue their involvement with the project if they felt it was not what suited their needs and interests. No one dropped out however and everyone seemed excited yet apprehensive at the prospect of working with the materials. They were to be 'pioneers' because this was to be the first time these materials were to be used in Irish primary school classroom.

## Learners of various experience levels can effectively work together

The structure of the initial workshop was critical in setting the focus and direction of the learning process but also in laying the foundations for sustaining the initiative. There was the real possibility that the unfamiliarity with the materials coupled with fears of inadequacy and failure would overwhelm this first group of nine teachers. After consultation with the teachers, a small number of children and parents were invited along to the first two days of the first workshop. Schools were asked to base their selection of parents and children, on a mix of gender and age as well as people who were naturally interested in building things and using technology. I felt this variety of experience levels and worldviews would inspire and drive the type of projects that could be developed. Parents especially those who may have experience in the mechanical of technical fields would offer an alternative perspective to the teacher as to what could be possible with these materials. From the children's perspective not having these materials normally in school added to the 'fun' element of the workshop and because they did not associate these materials with school-type activity they would perhaps be more willing to take risks and think outside of the box.

The teachers were willing to cooperate with this joint workshop format, as they were aware of the fact that this was a very new venture they were embarking on and that they would need the support of the parents as the project developed. The teachers also recognised that it was beneficial to have some children from their class becoming familiar with the materials, as quite often it was the children more so than their teachers who were often more comfortable with building materials and technology. It would also be an added bonus to have a few extra pairs of hands who could help out when they began working with the materials with the other children in the class.

## Learning is an equitable shared relationship

The workshop ran over a Saturday and Sunday to facilitate parents participating due to work commitments. There was an equal representation of adults and children coming from each school – two teachers, two parents, four children and perhaps the school principal. Having this balance, we hoped was sending the message that all learners were on an equal par and deserving of the same representation irrespective of age. It was also making the statement that the education of the children required input from not only the teacher but also the parents and the children themselves and that learning was an activity that was not the exclusive preserve of schools to control.

### Learners were capable of setting their own learning goals

The mix of children, parents and teachers proved to be an invaluable combination. The children and some of the parents, who were avid builders themselves, dived in and very quickly prototypes of models were being put together. The range of possibilities the materials presented to them increased exponentially once they realised that motors and sensors could be incorporated into their models, and could subsequently be programmed to control behaviours. It was interesting to see the teachers who would normally be 'in command' as it were, take a back seat for the most part as they watched with interest the wonderful models the children were creating together with the parents in each of the groups.

### Official recognition of teacher decisions helps towards taking control

After the first two days working with the parents and children the teachers then continued themselves over the next three days with substitute cover being provided for their classes. Having substitute cover to participate in a workshop was sending the message to these teachers that it is important to spend time on their own learning and development. It also confirmed that teacher chosen learning projects were on the same footing as mandated national programmes as this project had been given the same status in the system's eyes with official release days being sanctioned and substitute teachers paid. This was a positive step and a demonstration to the teachers that the time spent at this workshop was worthwhile and valued. From an organisational and administrative standpoint having substitute cover was very important for the day to day functioning of the schools contributing towards positive relationships with the school principals and the development of strong parental support.

### Creating a climate of expectation

Adding to the air of official status and approval for the ideas promoted by the project was the sense of occasion that we created on the first day of the workshop. Everyone had the feeling that they were part of something new and exciting that stood apart from the usual life of the classroom. Having the workshop at St. Patrick's rather than at one of the schools was important as it signalled to all involved that a respected, long established third-level institution was committed to the project and building relationships with teachers and children. It also demonstrated to the parents that a third-level institution was supporting the learning activities that the schools were about to embark upon. High-level people from the project sponsors, NCTE and *eircom* were present, as well as researchers from the U.S., demonstrating a high level of support and diverse interests in the project which helped to buoy up the confidence and enthusiasm of the teachers, parents and children.

### *Contextualising the materials within a narrative theme*

Situating the use of the materials within a narrative theme was key in creating a rich learning environment. This contributed to the immersive nature of the project as it provided a multidisciplinary focus to the projects that were developed. The idea of having a meaningful thematic approach to using the materials was conceived and decided upon by the teachers themselves at the first summer workshop (August 1999). The chosen theme of story, myth and legend had depth that encouraged originality and creativity but also gave some structure to the work the teachers and children were engaged in. It provided a focus yet simultaneously was open-ended enough to allow for individual interpretation satisfying a wide range of interests, experiences and passions. The different interpretations demonstrated that there is not one 'right way' to use the computational materials while also powerfully illustrating how a single theme can be widely interpreted.

The learning environment, subsequently created, was not prescriptive of how developments should happen but evolved from the teachers' and children's own interests and needs. The intention was that this would be a 'self-structured' sustainable programme of work or project. The pursuit and development of personal interest is reflective in the diversity of interests that have developed to date. The case studies will illustrate how the teachers have explored other technologies (e.g., Microworlds, video editing, data logging) to help them expand and deepen the learning they are engaged in. The group has in many respects become self-motivating and self-sustaining.

## *Where to from here?*

The teachers expressed that there is a tremendous sense of achievement and satisfaction when you have crafted a model that you have designed and created. Even the simplest model can become magical and precious once it is set in motion. Working with this set of expressive computational materials offers a learning environment in which learners are responsible for the conception, design, construction, programming and debugging of an autonomous robotic device or artefact. The immersive nature of the learning environment meant that the learning experienced by members of the group especially the teachers went far beyond this, as demonstrated in the later case studies. To begin with the LEGO Mindstorms materials used in the project were totally unfamiliar to the teachers and children. The majority of the teachers did not have a technical or engineering background so this type of learning was a new experience for them. The unfamiliarity with the materials was advantageous in many respects for not only did it level the playing field as no one had the advantage of prior experience so it meant that the teachers worked and learned alongside their students. It also slowed down the learning process and enabled the teachers to reflect on what it feels like to learn something new, to experiences the frustrations and then the delight when something works and to appreciate the different learning styles within the group. It was the first time that many of them had reflected on their own learning style and indeed some of them for the first time in their lives experienced real difficulty when trying to understand a new ides or concept. This not only made them more aware of how complex learning is, but also enabled them to empathise in an authentic way with the difficulties the children were having learning in their classroom. They began to think about their role as teachers, the relationships with members of the group and with the children in their classrooms.

The 'thinking about thinking' initiated at the immersive workshops could only be sustained if there was some way of bridging what went on at the workshops to the daily reality of these teachers. There had to be a way of embedding this thinking in a context that continued to be meaningful to these teachers.

# The challenge of sustaining a powerful learning environment

## *Emergent design*

A central goal of the Empowering Minds project was to design a learning environment, which would enable teachers to become self-determined learners. As the African proverb states: "If you give a man fish he will be hungry again but if you teach him how to fish he will never go hungry."

Using this analogy we believed that focusing on empowering teachers to think about thinking could lead to substantial change in the way learning is understood in school. This culture of 'learning how to learn' would become self-sustaining - continually growing and developing as the learners extend the boundaries in their quest for self-determination. Informed by these principles an "emergent design" (Lincoln & Guba, 1985; Hammersley and Atkinson, 1983) with an evolving supportive framework was put in place for sustaining this developing learning culture. Adopting an emergent design

> is the recognition that certain systems are too complex, dynamic, interconnected and chaotic to attempt to manage them by top-down, pre-planned, rigid means of control. ... if one is to follow the interests and expertise of the learners one must be prepared to adapt and continuously revise plans and activities (Cavallo, 2000 p.225).

An emergent research design with an evolving methodology therefore was a natural fit for the EM project as it "is particularly suited to coping with the unexpected and ephemeral [and]...is an effective means of rebutting the charge that the researcher merely superimposes his 'prejudiced' perspective on the data" (Sugrue, 1997, p.36). The emphasis instead "is on discovery, on finding out what life is like for people in the setting of interest- on learning, not testing preconceived ideas" (Jones 1996, p.44). The methodology remained 'flexible' (Bodgan and Biklen, 1982, p. 55) so that the 'strategy and even the direction of the research ...[could] be changed relatively easily' (Hammersley and Atkinson, 1983, p. 84).

## *Breaking the Mould*

Understandings of change are often simplistic and closely tied to how knowledge is understood. If knowledge is viewed as being fixed and transmissible, teachers and their students are viewed as knowledge users or consumers rather than knowledge generators or producers. Correspondingly changing teachers' practice is viewed in a sequential and predictable mind-set. Teacher courses therefore tend to be 'delivered' by 'experts' and very soon develop into the 'quick-fix' or 'one size fits all' model that is very linear and mechanised. Changing teachers' practice is thought possible with a single decontexualised prescription rather than demanding a complex process directly related to the context the teachers find themselves in.

If on the other hand you accept the provisional nature of knowledge, change becomes a complex process that is interactive and dynamic. Teacher learning is a lifelong process, contextualised and embedded in 'practice'. Rather than just being approached in a systematic and formal way it is recognised that learning is often indirect, incidental and informal. Learning is a prolonged process that takes time and needs a flexible support structure within which teachers feel 'safe' to take risks. Consequently the learning environment needs to be respectful and accepting of difference and responsive to teachers' needs, interests and experiences. Within the Empowering Minds project to support each individual teacher's learning great attention was paid to the design of the learning environment to ensure that structures were put in place that took cognisance of the factors highlighted in the literature as being crucial for teacher learning in particular:

- The structuring of ongoing *collegial support* and provision of meaningful *time*. Lack of support has been one of the key elements missing from most initiatives targeted to teacher development. However this support cannot be assumed to exist and must be carefully and systematically cultivated (Sugrue et al., 2001,p.40) in order that learners feel safe (Maslow, 1972) as real learning involves risk taking.
- A strong commitment to allow teachers *control* of the learning process, "to identify their own needs and to determine how they will facilitate their own learning."(Sugrue et al., 2001,p.45). Carl Rogers (1969) suggests that learning should be personally meaningful and relevant, as a person learns only those things that they perceive as being involved in the enhancement of self. However this self-directed process should not be carried out in isolation but should be informed by the stimulation and involvement of others.
- Focusing on the *classroom contexts* in which teachers find themselves and the importance of anchoring teacher learning to their everyday reality of their classroom experiences

Informed by a constructionist philosophy implicit in the design of the learning environment was also that teachers as learners should be active participants rather than a passive recipients; learning should be pleasurable even 'fun' and contribute to the development of self-esteem; the relationship between teacher and learner should be a more equitable shared experience with both involved and participating in the learning process together.

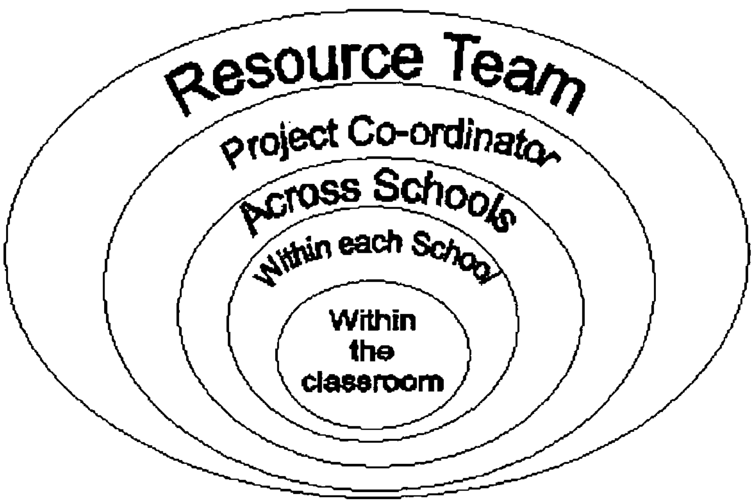
The remainder of this chapter will focus on discussing the three points outlined above, as they were instrumental in shaping the focus and direction of teacher learning within the Empowering Minds group. The development of a responsive support structure that was flexible and easily changed to support teachers' needs and interests was instrumental in helping teachers discover their own voice and take control. Feeling supported enabled them to take the risk of bringing the computational materials and the Atelier style of working into their classrooms. The anchoring of the teachers learning in the context of their everyday reality of the classroom experiences was probably the single most influential factor in how the teachers' understandings and beliefs about learning changed and developed over time.

### *Support Framework*

The prevailing approach to introducing technology into schools has been concentrated at the 'systems' level rather than the people involved in the system. The driving force is economic efficiency rather than the development of the individual. In contrast to this, we wanted the 'life force' to inform and direct teacher learning and their understanding of what being digital means for learning. This in turn would have a bearing on how our culture and organisations develop because it is individuals who change not organisations. To do this required that a supportive flexible support structure be put in place; as learning requires risk-taking and teachers should feel safe to explore and push beyond the boundaries. If something does not work out it should not be condemned as 'wrong' but seen as an opportunity to 'debug' or work out another way of tackling the issue. In fact it is often from our mistakes that we learn the most valuable things. This was generally a major point of 'unlearning' for many of the teachers who had experienced a system that did not encourage this exploratory approach. These prior experiences can result in many teachers being afraid to take the risk of 'being wrong' or of not 'knowing the answer' when confronted with using computational materials.

Creating a 'safe' environment is reliant on an open acceptance and active promotion of individuality and diversity of learning styles. The environment should not be restrictive or give preference to a particular mode of thinking or working. Multiple avenues of exploration should be encouraged and diversity celebrated. This was the thinking, which informed our workshops. However, initiating and building this 'learning culture' takes a lot of time. In addition a variety of evolving support structures are required to sustain the process of "learning about learning" (See Figure 12 below).

*Figure 12:* Support Structures




*Support within the classroom:*

Using the expressive computational materials and the same atelier style workshop approach that they had experienced the teachers began to design and construct similar learning environments for their own students. The teachers' own learning consequently was closely linked to the children's learning in their classrooms. It was the changes and developments that they witnessed in the classroom which concretised their understandings of the learning process. These experiences therefore became the richest source of learning, their 'object to think with', and the lens, through which they began to reflect upon and question what they understood as learning and their own role as teachers. All of the teachers agree that they have never learned so much about themselves and the learning process since beginning to work with the children as co-learners. Embedding the constructionist philosophy into the classroom context is at the heart of sustaining the development of this learning community. This idea is elaborated in the later discussion relating to teachers' classroom experiences as 'objects to think with'.

*Support within each school:*

With one exception, there were at least two teachers with a range of experience using digital technology from each of the selected schools. The lone teacher who was the school principal of a small two teacher rural school was very technologically fluent and incredibly enthusiastic about becoming involved within the EM community.

This mix of experience within schools we hoped could facilitate a natural 'buddy system', as the more experienced teacher could help out and encourage their partner teachers in the school. Having this supportive environment helps teachers take risks in safety, as they know if something goes wrong a helping hand is always available to provide advice and support. As one of the teachers remarked "having someone in the school or at the other end of the phone takes the fear out of trying out things. I'm no longer afraid to get myself into a mess because I know if I can't sort it out one of the others will give me a hand." (Barbara's remarks, observation field notes / Interview June 2000).

*Support across schools:*

From a logistics' perspective a small number of schools were selected for the initial phase of the project. Having small numbers would I believed would also maximise the development of good relations. A strong sense of rapport was built up among the group over the course of the workshops. This building of a group identity has continued with the second group of teachers. A key factor was that the teachers from the first phase worked closely with all the new teachers during their first five-day summer workshop. They were on hand to answer all queries about day-to-day management and organisational issues, materials, common pitfalls, etc. This did much to ally the new teachers' fears and apprehensions and build their confidence. This positive presence of the first phase teachers demonstrates the potency of peer endorsement. As the number of schools was extended from 4 to 13, structures where put in place to help continue this valuable peer support. School visits were facilitated and three clusters were formed with a mix of phase one and phase two schools in each. These clusters of schools acted as a source of ideas and inspiration for one another, as well as providing advise about issues as they arise e.g., classroom management and organisation of materials. Initially cluster meetings were organised but as the group developed and diversified these clusters have become more an organisational structure for sharing equipment (e.g., video cameras). Regular group meetings using St Patrick's College as a base were, and continue to be, organised with teachers sharing ideas and helping each other with specific problems they may be having. If there are a number of teachers interested in a particular topic a mini-workshop is organised so that those who have more experience in the area can offer help and advice. Detailed notes of each meeting are recorded and posted on the website for those who had not been able to attend (http://empoweringminds.mle.ie).

(See Appendix E for a more detailed description of these support structures and how they developed in response to the needs of the group)

*The project co-ordinator as support:*

The regular school visits and meetings with teachers by the project co-ordinator (Deirdre Butler) provided an opportunity for help and advice to be available as the need arose (See Appendix E - Classroom visits and reasons for their importance). In the second phase of the EM project development the number (4 to 13 schools) and geographical spread (Sligo, Louth, Kilkenny, Kildare, Tipperary and Dublin) of the schools was expanded so it was not possible to make as many visits to each individual classroom. In an effort to compensate for this, structures were put in place to facilitate teachers visiting and working with teachers and children in the other schools. Some teachers brought all their students with them when visiting one of the more experienced schools as they felt it would be a much more powerful learning experience than if they just went alone. These visits provided a platform for cross-fertilisation of experiences, skills and ideas that were further developed at regular group meetings for participating teachers.

Consistent with the interactions I had with the teachers during the workshops when I visited the classrooms I worked alongside the teacher and the children as they developed their projects. I was available when needed to offer advice and suggestions to help towards solving their problems. The basic underlying philosophy of how people interact in this type of learning environment is the same regardless of age or position. There was and continues to be no hierarchical structure but an emphasis on a sharing of experiences and each helps the other in whatever way possible. It is always a dialogue of experiences and never a usurping of power or control. Control is always vested in the learner, as they are responsible for their own learning. My role changed over time. The need for my visits to classrooms diminished once the teachers became confident using the materials in their classrooms and they began to lean more on each other for help and support.

*Resource Team support:*

These people (e.g., Fred Martin, Glorianna Davenport, Media Lab Europe/MIT media lab researchers, NCSR personnel) provide expertise, advice and an alternative perspective to the group. They have a range of diverse backgrounds with some also having prior experience of working with the computational materials in a variety of settings with different communities.

### *Control of the learning process vested in the learner*

In the Empowering Minds project we wanted to create a learning environment where learning -especially teacher learning - can move towards self-direction. In order to begin moving towards self-direction each individual must take responsibility for this development from the outset. For this reason all teachers in the Empowering Minds project volunteered their participation from the beginning and there was never any compulsion for an individual to remain part of the group. Everyone was free to draw back or drop out whenever they decided to. Participation at all workshops, group meetings, exhibitions or any other event was not mandatory.

Another critical factor in the development from dependence to self-direction is that the teachers' experiences, needs and interests informed the direction and focus of their learning. Having your own interests and needs to the forefront in deciding what is to be learned ensures the process is meaningful and you have ownership of it. Otherwise you are answering other people's questions rather than setting your own. Democratic decision-making was consequently a defining feature of the development of the learning environment to enable teachers to be in control and responsible for their own learning. However we did make deliberate decisions about the structure of the initial workshop (Easter 1999) in order to gently nudge the teachers into taking control of their own learning.

Taking control assumes teachers have the courage to take a risk. However to take a risk you must feel safe so 'safety nets' and support structures have to be put in place to help the teachers and empower them to take risks. Taking cognisance of this fact from the very beginning teachers fears and anxieties were sensitively listened to and structures put in place to help them feel safe in continuing.

#### *The needs and interests of the learner fuelling the learning process*

The teachers expressed what they felt was necessary when I visited the classrooms or at workshops particularly during the reflective discussion sessions. It was noted by the teachers that each suggestion was acted upon, which increased the teachers' confidence to articulate their needs. Responding to their requests also contributed to the building of an ethos of trust as is demonstrated later in the teacher case studies. Gradually, over time as we listened intently to the teachers' feedback and responded to their needs and interests - the teachers began to take control of and responsibility for their own learning.

Consistent with the emergent design approach, the design and development of the learning environment and the support structure framework went through a number of phases (See Table 1). This development was closely related to the teachers' interests and needs as we acted on their feedback and what they indicated was necessary.

Table 1: *Stages of development of EM project 1998-to date*

| | | |
|---|---|---|
| **EXPLORATORY** | OCT. 1998 – APRIL 2000 | 4 SCHOOLS / 9 TEACHERS / COMMON SET OF COMPUTATIONAL MATERIALS WORKSHOPS / FREQUENT CLASSROOM VISITS |
| **Expansion** | May 2000 – June 2001 | 13 schools / 29 teachers/ common set of computational materials Workshops / classroom visits /cluster meetings/ buddy system |
| **Deepening & Sharing** | June 2001 – May 2002 | Variety of new technologies explored (e.g., Microworlds, digital video) Workshops / Group meetings / email / Web platform developed |
| **Reaching out** | June 2002 – to date | Expanding beyond the 13 schools – teachers as self-determined learners. |

## "Gearing" (conceptual /skills development) needs

To demonstrate this constant interaction between the teachers' needs and interests and how workshop and other learning opportunities were developed in response to this, an outline of the workshops and reflective sessions that were developed over the five years of the EM project to date is included in the appendices (See Appendix E). For example as a result of the classroom exploration of materials (May-June 1999) the first group of teachers made specific requests for the summer workshop content as they realised the need to develop their own understandings of the principles of building solid structures, how gears worked, , etc. These inputs were acted upon and the second workshop was designed to accommodate the teachers' expressed needs. Consequently we used a substantially more structured format in this second workshop, providing teachers with focused half-day experiences rather than a multi-day open design process. These half-day focused activities proved invaluable for helping the teachers gain some important insights e.g., Slow car challenge, The Silent game (See Appendix E).

### The need to share

The teachers' expressed need of being part of a larger group within which they could comfortably share ideas was also invaluable in forming a common focus and cohesion to the group. However it was not always feasible to have face-to-face meetings so alternate ways of sharing experiences had to be found. The teachers discussed how they might share what was going on in their classrooms and had thought that if they each had a website then it could act as a window into their classrooms. As a result of this feedback a variety of software was reviewed; and a one-day web development workshop was organised (Feb. 2001). Some of the teachers developed their own websites but the majority of the teachers due to lack of time and technical expertise did not manage to do so.

The problem of how to share experiences across classrooms still remained as a pressing need for the teachers and was a constant topic for discussion. The teachers realised they had to prioritise their needs when the SIP initiative ended and official release time ceased in June 2001. They could not come together as often or as easily as in previous years because official release time was not being sanctioned. They decided that communication and the sharing of ideas and expertise was to be their first priority. A concerted effort would have to be made to have a means to communicate across all the project classrooms. Wireless hardware was thought to be the most appropriate solution to this connectivity problem. It would enable multiple machines access the web from the same connection without having to interfere with the structure of the school to install cabling. However connectivity was only one part of the solution. In addition to having connectivity teachers needed a platform on which to share their learning experiences and as a means of getting help and support for the problems they were experiencing. To this end a web platform (http://empoweringminds.mle.ie ) was also designed and developed with the teachers (cf., Butler et al. 2002) and is still currently being used by the group as they collaborate and share their distributed expertise. As a result of this strong need expressed by the teachers this connectivity became the focus for the 2001-2002 school year.

The need to express meaning Expression needs

The palette of computational tools and materials was also expanded as a direct result of the teachers' needs and interests. Many of the teachers had expressed an interest in learning more about how to use picture and video, for example, to tell a story and help capture some of the learning processes they were observing in their classrooms. Glorianna Davenport who directs the research of the Interactive Cinema group at MIT ML, was extremely generous in giving her time to help the teachers develop this interest. She extended invitations to the teachers to cooperate with her research group (e.g., Master class with the world renowned filmmaker Ricky Leacock). She also worked with the teachers during workshops, exploring issues of light and perspective as well as helping the teachers articulate their stories using digital imagery. As outlined in the case studies the teachers gradually began to realise how digital imagery can be a powerful medium for expressing meaning. This interest has developed to using digital video.

The range of computational materials and structures necessary to support the teachers broadened as the teachers began to become more self-directed. They began to take a more active role and accepted responsibility for determining the direction of their own learning. The project development outline (See Appendix E) indicates the type of evolving support structure and the range of computational materials used by the group.

### *Classroom Experience – 'an object to think with'*

The teachers had a huge wealth of classroom experience ranging from one year to over thirty years teaching. This experience was shared as the group grew in trust and respect for one another. As noted earlier a teacher's practice is informed by their 'meaning perspective'. What and how they teach is informed by the beliefs and values that have been developed and informed by their past experiences and the groups to which they belong. This valuing of the teachers' prior and ongoing experiences in the classrooms was of critical importance. If there was going to be any change in how these teachers viewed the learning process it was only going to be if they themselves constructed "their own understandings of their work and roles and adapt according to their beliefs and positions" (Cavallo, 2000, p.225).

Peter Senge (2000) noted that nothing in schools or other organisations changes unless individuals' beliefs, ways of seeing the world, skills and capabilities are given an environment conducive to change. However our beliefs and attitudes are firmly entrenched and can in turn only be changed as a result of experience. Robert Lindberg (1995) reminds us that although belief must underlie a permanent change in human behaviour, belief is most likely to follow behaviour rather than to precede it (See Figure 13).

*Figure 13:* The relationship between Experiences, Beliefs and Attitudes

**Experiences** ⟺ **Beliefs / Attitudes**

Taking cognisance of this observation it was decided to design an immersive learning experience for teachers and support them as they appropriated the computational materials in personally meaningful ways and began thinking about thinking. The choice of computational materials and the Atelier-style learning approach underpinned by a constructionist epistemology served to "encourage dialogue, self-expression, community and reflection" (Ueda, 1999) and posed a challenge to the teachers' existing learning beliefs and assumptions. This enabled teachers to build a set of experiences, which are very different from their prior understandings of learning. However the workshop experiences alone would not lead teachers to question deeply their strongly entrenched beliefs and assumptions about learning. Sustainability was an issue, which had to be seriously addressed if teachers were to become self-determined learners. The 'thinking about thinking' initiated at the immersive workshops could only be sustained if there was some way of bridging what went on at the workshops to the daily reality of these teachers. There had to be a way of embedding this in a context that continued to be meaningful to these teachers.

Papert has suggested that this thinking about thinking "happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity whether it's a sand castle on the beach or a theory of the universe (Papert, 1991 p1). Teachers' understandings of learning are rooted in their classroom practice so it was natural to anchor their own learning to this everyday reality. Anchoring the teacher's own learning with the computational materials in their everyday reality of the classroom concretises the learning process for them. This allows teachers to use their own teaching practice as 'an object-to-think-with' (in the constructionist, Papertian sense). Each teacher's context is different which means that their needs and interests demand a different set of supports so a single prescription could not apply to each teaching and learning situation. Flexibility and appropriateness were to be the key to sustainability.

Using the computational materials and Atelier workshop approach the teachers began to construct a different learning environment for their students. It was the learning that the teacher experienced and witnessed in their own classrooms which then became their 'object to think with' as they, together with their students built concrete artefacts using the expressive computational materials. The teacher's own learning consequently was closely linked to the children's learning in their classrooms. Some may argue that this is not anything new as "learning by doing" is an idea that has been around for some time. However I would agree with Papert's argument that "until recently the narrowness of range of the possible doings severely restricted the implementation of the idea. The educational vocation of the new technology is to remove these restrictions" and enable "a restructuring of knowledge itself" (Papert, 1991, p.22). It was the changes and developments that they witnessed in the classroom which concretised their understandings of the learning process. These experiences therefore became the richest source of learning for teachers, their 'object to think with', and the lens, through which they began to reflect upon and question what they understood as learning and their own role as teachers. At the same time, these experiences also gave them encouragement to continue with the project.

Outlined in Appendix F are some of the common classroom experiences, which confronted the teachers deeply held beliefs about learning. Reflection upon these experiences lead to a change in teachers' understanding of what learning is, their role as teachers and their relationship with the children they work with. It is hoped that this general flavour of the challenges, which all the teachers faced and the questions about learning they provoked will serve as a backdrop for the later more in-depth individual teacher case studies.

The workshop experiences would soon have become nothing but a faded memory unless it was anchored in the teachers' everyday reality of the classroom environment. The EM methodology was to develop Atelier style workshops and then extensively support the teachers with their own styles to bring the computational materials and learning approach into their classrooms. Bringing the computational materials and style of working back to the classroom was a challenge and these new experiences stimulated them to question their existing practices. Support structures were developed to meet the teachers' needs as they arose. The teachers expressed what they felt was necessary when I visited the classrooms or at workshops particularly during the reflective discussion sessions. It was noted that each suggestion was acted upon, which increased the teachers' confidence to articulate their needs. Responding to their requests also contributed to the building of an ethos of trust. The support structures that were developed (e.g., ongoing workshops with building activity followed by reflective discussions; group meetings; classroom visits; cluster groups; buddy system, e-mail, web-based platform) formed the framework for sustaining this valuing of classroom experiences. This enabled the teachers to continue to collaborate, reflect and critically evaluate their own learning and what was happening within their classrooms. It ensured that once the process of thinking about thinking was initiated it would be capable of continuing and empowering the teachers to become self-determined learners. This 'knowledge of practice' (Cochran-Smith and Lytle, 1999) places each teacher at the centre of his or her own problematic practice. It is an ongoing process that develops over time with others in a learning community as a result of reflective inquiry (Schön, 1987). Teacher professional development can then be understood as a learning process that takes cognisance of the personal, social, historical and physical contexts of the teacher as learner.

# Chapter Four
# CAPTURING TEACHERS' EXPERIENCES

In the previous chapter, I focused on the design and description of the learning environment in which the Empowering Minds teachers were immersed, the computational materials they used, and the strategies used to sustain their "learning about learning". What follows is a description of the ways Empowering minds captured the teachers' experiences: As they faced the challenges and threats of this new style of learning, how were they thinking about learning? How were they attempting to redefine their meaning perspectives as a result of their experiences within the emerging learning culture of the EM project? The four teacher case studies that emerged are presented in the next chapter in order to interrogate the question posed by this study:

> Can immersion in a collaborative Constructionist learning environment rich in computationally expressive materials, challenge teachers to question assumptions and beliefs about learning, and empower them to become self-determined learners with a critical awareness of what being digital in learning can mean?

## *Why Qualitative Research methods?*

All classroom life is complex: policy issues, teachers' intentions and actions, their understandings and beliefs about learning, their experiences in life, the context of their work, and their understanding and use of digital technologies are all intimately and inextricably linked. Unravelling the links and related factors is a complex and demanding task that I could not have attempted without the in-depth collaboration and participation of teachers in a long-term project. Because change happens slowly, this study had to take place over a number of years to allow sufficient time for a new culture of learning to develop. With a longitudinal approach, I was able to "develop a relationship with the subjects that allows for the exchange of relevant information." (Strohecker, 1991, Chap. 3, p.1). I took great care to ensure that "the work [was] both frequent enough ...and open-ended enough for differences in style to emerge" (Turkle and Papert 1990, 353).

From the outset, I knew that this study would be useful only insofar as I attended to the teachers' voices as they began to develop understandings of their own learning. Their input would, in turn, help inform the development of powerful learning environments for others. Consequently I wanted to make every effort "to understand [these teachers] ... by entering into their field of perception in order to see life as these individuals see it" (Bruyn, 1966, p. 90). As I tried to understand the learning processes and styles of the Empowering Minds teachers and their emerging understandings of what being digital can means in learning, I relied upon qualitative research methods as they are particularly suited to uncovering meanings people assign to their experiences (Hoshmand 1989; Polkinghorne 1991). The key characteristics of this research method are documented in Table 2 below (adapted from Cresswell 1998, p.16, Table 2.1 )

Table 2: *Characteristics of Qualitative Research*

| Characteristics of Qualitative Research | | | |
|---|---|---|---|
| | *Bogdan & Biklen(1992)* | *Eisner (1991)* | *Merriam (1988)* |
| Natural setting (field focus) as source of data | Yes | Yes | Yes |
| Researcher as key instrument of data collection | Yes | Yes | |
| Data collected as words or pictures | Yes | | Yes |
| Outcome as process rather than product | Yes | | Yes |
| Analysis of data inductively, attention to particulars | Yes | Yes | Yes |
| Focus on participants' perspectives, their meanings | Yes | Yes | Yes |
| Use of expressive language | | Yes | |

Qualitative methods also emphasise "the researcher's role as an active learner who can tell the story from the participants' view rather than as an 'expert' who passes judgement on participants" (Cresswell, 1998, p. 18). I knew I would gain nothing if I felt from the outset that I was the "expert" who knew all the "right" answers. If I were to approach the project from such an angle, I would only propagate the message of the "one right answer" approach to learning that I was struggling so hard to fight against.

Qualitative research is multi-method in focus. Because it involves an interpretive, naturalistic approach to its subject matter, qualitative researchers study their subjects in their natural settings, they try to make sense of or interpret phenomena in terms of the meanings people bring to them. Qualitative research involves the studied use and collection of a variety of empirical materials. It employs case study, personal experience, introspective life story, and interview, plus observational, historical, interactional and visual texts that describe routine and problematic moments and meaning in individuals' lives (Denzin & Lincoln, 1994, p.2).

The interpretive methods (Erickson, 1986) I employed for this exploratory study involved the collection and interpretation of qualitative data over a five-year period. Interpretive inquiry was particularly suited for this study as it:

> aims to transform the consciousness of practitioners and by so doing … give them grounds upon which to decide how to change themselves …[I]t assumes practitioners are free to make up their own minds about how to change their practices in the light of their informed practical deliberations. (Carr and Kemmis, 1986, p. 219)

So rather than introducing digital technologies without questioning the existing structure of classroom learning environments, I believed it was necessary that teachers should have the opportunity to explore how their own conceptions of learning, and the ways these conceptions influence the learning opportunities they structure for their students. Hargreaves (1992) also stressed the importance of teachers reflecting upon their own learning assumptions when he argued that:

> Teachers don't merely deliver curriculum. They develop, define and reinterpret it too. It is what teachers think, what teachers believe and what teachers do at the level of the classroom that ultimately shapes the kind of learning that young people get (Hargreaves, 1992 p.x).

I believed that if teachers engaged in challenging learning experiences that helped them understand their own learning, they would naturally see alternative ways of structuring learning environments for their students because to "understand in a different way" increases potential for alternative actions (Gadamer, 1975, p297; Dunne, 1992; Grundy, 1987).

As Kirk and Miller (1986) pointed out, long-term personal interaction of participant observation provides an understanding of a setting that cannot be attained with any other research method. Working with these teachers in their natural settings as a participant observer for the last five years, I got to know them all personally through the many experiences we shared. I got to "see the whole, in all its complex, dynamic reality and not just bits and pieces" (Jones, 1996, p.68).

Data were collected using field notes, photos and video footage of classroom visits and teacher workshops, open-ended and scheduled focused interviews (recorded, transcribed), e-mails within the group, and recorded notes of group meetings as well as notes from group and individual conversations. By documenting the multiples realties of classroom practice in this way, I was able to ground my understanding of the ways digital technologies can challenge understandings of learning – particularly the teachers' roles, and their relationship with their students – in ways that respect the voices of the teachers and the problematic nature of digital technologies, learning and teacher development.

From these composite layers, I began understand their routine and problematic moments as they struggled with the challenges of coming to terms with these new computational materials in a Constructionist-learning environment. I also began to uncover what brought meaning into their lives as teachers, and how they began to understand their own learning. Using a story based narrative I have tried to capture these teachers' journey to understanding the process of learning by using expressive computational materials; the ways they have begun to question their beliefs and assumptions about learning; and the ways this process of "learning about learning" has been sustained.

## ***Researcher bias***

We must acknowledge that "qualitative researchers approach their studies with a certain paradigm or worldview, a basic set of beliefs or assumptions that guide their inquiries" (Cresswell, 1998 p.74). Sherry Turkle (1984) argues that

> [T]he very process of research is interpretive. In writing about ethnography, Clifford Geertz has stressed this fundamental fact: "what we call our data are really our own constructions of other people's constructions of what they and their compatriots are up to. ... Right down at the factual base, the hard rock, insofar as there is any, of the whole enterprise, we are already explicating; and worse, explicating explications. Winks upon winks upon winks" (Turkle, 1984, p. 315)

So I have to clarify researcher bias from the outset of the study, in order the reader to understand my position and any biases or assumptions of mine that may impact the my inquiry (Merriam, 1988). In this clarification (See Preface: Personal Context) "the researcher comments on past experiences, biases, prejudices and orientations that have likely shaped the interpretation and approach to the study" (Cresswell, 1998, p.202). I could say that every study is prejudiced in the Gadamerian sense of the term (1975, p.270), but by adopting an emergent research design I have at least employed " an effective means of rebutting the charge that the researcher merely superimposes his 'prejudiced' perspective on the data" (Sugrue, 1997, p.36). The emphasis of Empowering Minds is "on discovery, on finding out what life is like for people in the setting of interest – on learning, not testing preconceived ideas" (Jones, 1996, p.44). A design emerged as I engaged in "continuous data analysis so that every act of investigation [took] into account everything that has been learned so far" (Lincoln & Guba, 1985, p.209).

## *Data Collection*

Initially I took the "big net approach" (Fetterman, 1989 p. 42). I had to build a comprehensive portrait of these teachers' lives if I were to understand how they appropriated the computational materials and worked with the children in their classrooms. In order to cast my big net, I would have to spend "extensive time in the field… trying to gain access, rapport and an 'insider' perspective" (Cresswell, 1998, p. 17), so "negotiating entry and cultivating good field relations was important" (Sugrue, 1997 p.40).

Because I work in the education department of a respected third level institution, and I am a reasonably well-known former mathematics educator, I was readily welcomed into schools. Thanks to my background as a teacher with close to 20 years' classroom experience I understand and appreciate the realities of classroom life. Building rapport with teachers was relatively easy because I could identify and empathise with their problems and difficulties as well as understand the various types of constraints under which many of them worked, and I speak their language. I also know something about the management and administrative difficulties involved in the organisation of schools as, for a number of years, I was a vice-principal of a medium-sized (10-teacher) primary school. So to some extent, having formerly been an insider, I already had "insider's perspective" to school culture and was accepted cordially by all the schools as a resource and a welcomed frequent visitor. They regarded my visits as unobtrusive, and a quiet, easy relationship developed between the teachers, the children, the school principals and me. As a result of the exhibitions and demonstration events EM were involved with, such as local school open evenings, and Young Scientist exhibitions, I also developed good relations with many parents, who generously gave me their views of the project and the learning activities their children were involved in.

Aware of the dangers of "interpretative" research, I built as composite a picture as possible. To make the different teachers thinking explicit, I used a variety of data collection and analysis methodologies. The data I collected over the five years of the project to date include:

- Interviews:
  - the first set of teachers at the end of the first phase (June 2000)
  - the second set of teachers before they began working with the materials (Sept 2000)

- the subset of teachers I selected to work with when developing the case studies (July – December 2002)

- Teacher reports, June 2001

- Conversations with individual teachers during visits to classrooms, workshops, group meetings, etc.

- Field notes / observation notes (Classroom visits, teacher workshops)

- Compilation of learning stories (e.g., Mexico, Digital video workshop interviews, classroom visits)

- Digital photos from classrooms and other EM project-related events (e.g., Young Scientist Exhibition, local open school events)

- Digital video footage of classrooms and workshops

- Web platform - http://empoweringminds.mle.ie , a data-based repository for photos and other media, documents developed by group, mailing list archive, forums

- Emails in addition to those from the mailing list

- Interviews with the thirteen students from the undergraduate Digital Learning Elective course who worked with the project teachers and children in their classrooms

- Undergraduate Elective students' digital journals

By using these data collection techniques, I was able to capture the natural diversity in people's thinking, and to get more fully in touch with the "deep structures" (Lane, 1970, p.15) of the teachers' thinking about what being digital in learning means for them, and the implications it has for their role in the classroom.

The data collection techniques listed above need little explanation with the exception of the approach that was used for the extensive number of interviews that were conducted by the researcher.

### *Interview*

To gain insight into the teachers' perspectives on their own learning and how participation in the project had contributed to these perspectives, I used in-depth, semi-structured, and open-ended interviews as the dominant strategy to capture phenomena in teachers' own words (Bodgen & Bilken, 1992). Mindful of Spradley's advice (1979, p.78) that the interview process involves two "complementary" dictates of "developing rapport" and "eliciting information" I followed Sugrue's lead (1997, p.37) and "trod a middle ground between a very 'exploratory' structure and a 'depth' and 'focused' approach"(Lincoln & Guba, 1985, p.268).

I decided "not to decide beforehand" the sequence and pace of the interviews but I did "enter the interview with a list of issues to be covered" (Hammersley and Atkinson, 1983, p.113). My prepared "interview guide" (Jones, 1996, p.141) contained a list of issues in the form of questions. By drafting and redrafting questions I was able to frame appropriate questions that both helped to avoid bias and did not cue the interviewees to provide particular answers.

The "interview guide" also helped focus the interview initially, but it did not dictate the pace or direction. I remained free "to make decisions about how and when to ask questions based on what [was] already known, or [could] be judged about the respondent ...and the feedback obtained during the interview" (Jones, 1996, p.141). I used my interview guide as an outline to help remember what to ask, and to cue me to recognise relevant information from the interviewee even if that information did not come when I expected it to (Stewart and Cash, 1991). I took very seriously my responsibility to listen very carefully and to "use the information that the participant was providing to ensure continuity and structure as well as to enable me to change focus when necessary" (Sugrue, 1997, p.38). Researchers who do qualitative interviews generally agree that tape-recording and transcribing are essential (e.g., Mishler, 1986; Mc Cracken,1988; Seidman, 1991; Weiss, 1994). Mc Cracken insists, "Interviews must be recorded on tape...Interviewers who attempt to make their own record of the interview by taking notes create an unnecessary and dangerous distraction" (1988, p41).

Each teacher participated in two or three interviews ranging from 30 minutes to one hour duration that were recorded (initially using a minidisk recorder and later using a digital voice recorder with memory stick) and transcribed verbatim. This recording and transcription allowed for accurate reporting of the teachers' responses and enabled me to interpret specific responses in the context of the entire transcript. In keeping with Erickson's recommendations (1986) all data across the interviews was examined closely to identify common patterns and as patterns began to emerge I began systematically searching the data for evidence to support the emergent themes.

Bogdan and Biklen point out, by its very nature, the "qualitative interview project is cumulative" and "it is what you learn from the total study that counts" (1982, p.137), so my interviews and their data analysis progressed in tandem. As particular themes began to emerge over time, I constantly reviewed the nature of questions and range of issues to be covered in each interview.

Mindful of Agar's advice to "Immerse yourself in the details, trying to get a sense of the interview as a whole before breaking it into parts" (1980, p.103), I read the transcripts in their entirety several times, as I attempted to analyse the data from the teacher interviews. Significant statements were then extracted from each interview and formulated into meanings, which were then clustered into themes. Finally, I integrated these themes into the narrative descriptions in each of the relevant teacher case studies.

## Data Analysis

My EM work has been a study in multi-tasking: I collected and interpreted data while simultaneously adapting the learning environment in response to the group's needs and interests. The most difficult part of this process has been sifting through the accumulated data to tell the story of how the group has developed and how individual teachers have begun to learn how to learn. There was the temptation to try and tell everything, but beginning with a "wide angle lens" (Spradley, 1980 p.56) and through progressive focusing over time, a number of salient themes began to emerge, illustrating the deep connections and understandings the teachers have developed about what learning can be and what being digital can mean in learning.

I had to identify and select particular themes and ideas to focus on, as it is impossible to give equal attention at once to all aspects of a complex situation (Hammersley & Atkinson, 1983). Hatch's (2002) steps in typological analysis were useful initially in providing a framework for helping to organise the multitude of data, to formulate categories for further analysis and to help structure the development of the overall analysis (See Table 3 below).

Table 3: *Steps in Typological analysis*

| STEPS IN TYPOLOGICAL ANALYSIS |
|---|
| 1. Identify typologies to be analysed |
| 2. Read the data, marking entries related to the typologies |
| 3. Read the entries by typology, recording the main ideas in each entry on a summary sheet |
| 4. Look for patterns, relationships, themes within typologies |
| 5. Read data, coding entries according to the patterns identified and keeping a record of what entries go with which element of the patterns |
| 6. Decide if patterns are supported by the data, and search the data for nonexamples of the patterns |
| 7. Look for relationships among the patterns identified |
| 8. Write patterns as sentence generalisations |
| 9. Select data excerpts that support generalisations |

(adapted from Hatch, 2002, p152- 161)

The initial typologies were generated from the research questions and the review of the literature and were written in the form of questions (see Table 4 below), which I could use when examining the range of data. As the study developed other salient themes emerged (see Table 5 below) which were also incorporated into the data analysis.

In the process of determining common patterns in what I observed, I also paid close attention at the level of particular details, for it was often these finer details that helped me understand the individual participants and the complexity of each one's learning process. I focused on understanding and appreciating the participants' perspectives; only from their vantage points could I begin to understand how best to continue structuring a learning environment for these teachers that would, in turn, help them construct and expand their own learning.

Table 4: *Categories for Data Analysis drawn from research question and literature review*

| CATEGORIES FOR DATA ANALYSIS DRAWN FROM RESEARCH QUESTION AND THE LITERATURE REVIEW |
|---|
| Who is in control of the learning process in the classroom?<br>Do teachers reflect on their own learning experiences and /or on their students' learning experiences?<br>Are teachers aware of their own learning style?<br>Do classroom practices take cognisance of a range of learning styles?<br>Are teachers consciously aware of the epistemological understandings that are informing their classroom practice?<br>What is each teachers' predominant teaching style (Instuctionist / Constructivist) ?<br>What are these teachers beliefs about seeking the co-operation and collaboration of colleagues? |
| What role or function do teachers see computational materials having in their own and the lives of the children they are working with?<br>Are the computational materials being used to maintain the status quo in our educational system?<br>Does introducing the computational materials into their classrooms fundamentally change the way teachers interact with their students?<br>Do teachers tend to incorporate digital technologies by adopting those elements that serve their existing teaching style, rather than changing to match the opportunities the technology may offer? |
| What are teachers' understandings / expectations of professional development programmes?<br>Do teachers have a concept of being responsible for their own decisions and are they capable of self-direction?<br>Is the readiness of the teacher to learn critical for moving from one developmental stage to another?<br>Is the teacher's orientation to learning life-centred rather than subject- centred?<br>Is the teacher's accumulated wealth of experience a double-edged sword – does it enhance the learning situation, or possibly inhibit it?<br>Is learning affected by emotions, attitudes and beliefs? |
| When given adequate time, do teachers develop new classroom practices?<br>Is there evidence to indicate that teachers are moving beyond what Papert has termed 'the first impact' of the technology?"<br>Are teachers more aware of the process of learning as they reflect on what they do rather than just focus on the product or what is learned?<br>Is support at the level of the school necessary for teacher professional development?<br>Is ongoing collegial support necessary to meaningful and long lasting teacher change?<br>Are opportunities for reflective thinking necessary for teacher change?<br>Does a supportive community that encourages sharing and dialogue promote both trust and the risk-taking necessary?<br>Do changes in teachers' belief systems occur when they can attribute growth in students' learning to changes in their classroom practices ?<br>Can teachers use their own teaching practices as objects-to-think-with (in the Constructionist, Papertian sense), thereby externalising and examining their understandings of learning. |

Table 5: *Other Categories for Data Analysis which emerged over time as the EM Community developed*

| OTHER CATEGORIES FOR DATA ANALYSIS WHICH EMERGED OVER TIME AS THE EM COMMUNITY DEVELOPED |
|---|
| Did prior experiences the teacher had using technology influence how they reacted to the computational materials used in the EM community?<br>What was the role of the teacher's EM project partner in their school?<br>How did the teacher react to the Atelier-style structure of the first EM workshop?<br>Did the teacher incorporate elements of the Atelier style structure into their classroom e.g., discussions, collaboration, critique of work, reflection?<br>Did the teacher interact with the other members of the EM community?<br>Did the teacher see the other members of the EM community as a resource or were they threatened or inhibited by them?<br>Was being part of the decision-making process about the development of the EM community important to the teacher? |
| What classroom events influenced teacher's attitudes or beliefs?<br>Were there unexpected developments by particular children using these computational materials?<br>Did teachers consciously try to accommodate different learning styles?<br>Has the relationship between teacher and children changed?<br>Do the children interact and relate to each other differently?<br>Is there a change in the relationship between the home and the school?<br>What are the parents' reactions to the computational materials and the constructionist classroom practices? |
| Has there been a change in how the teacher defines their role?<br>Has there been a change in how the children understand the teacher's role?<br>Were the children's interests used as springboards for further learning experiences?<br>Did the teacher determine how the computational materials were to be used?<br>Who decided on the learning paths/experiences and which direction they should take?<br>Do teachers regard context (social, emotional, historical and physical) as important in learning?<br>Has there been a shift by the teacher in valuing the 'product' or the 'process' of learning?<br>Has the teacher a better understanding of how they themselves learn?<br>Has this realisation made they more aware of other learning styles? |
| Did the teachers value having a structure or shared context within which they could have conversations about their classroom practices on a regular basis?<br>Were there school barriers that prevented the teacher from engaging with the EM learning principles and philosophy? |

Unlike quantitative research where you can often have off-the-shelf, ready-made formulae or software packages to analyse your data, data analysis in qualitative research is custom-built, revised and "choreographed" (Huberman & Miles, 1994). As a result, many critics claim that qualitative research is largely intuitive, soft and relativistic, or that qualitative data analysts fall back on the three "I's" – "insight, intuition and impression" (Dey, 1995 p. 78).

Cresswell (1998, p. 142) counters this charge of softness, along with its implied value judgement, by explaining that in the process of analysing

> qualitative data the researcher engages in the process of moving in analytic circles rather than using a fixed linear approach. One enters with data of text or images ...and exits with an account or a narrative. In between, the researcher touches on several facets of analysis and circles around and around.

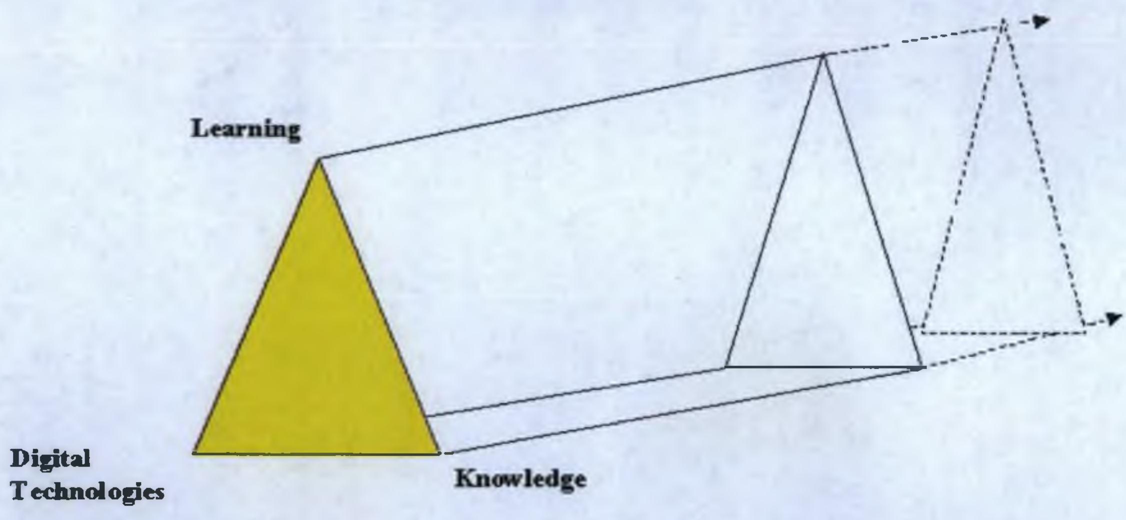
This inductive approach to developing the qualitative narrative is perhaps best described as a data analysis spiral: it "shows that the process is one of an emerging design" (Cresswell, 1998, p.74). Category formation is at the heart of qualitative data analysis; it is characterised by repeated analysis that reduces the number of files by eliminating some that appear insignificant and by amalgamating others (Hammersley & Atkinson, 1983; Spradley, 1979, 1980). This iterative process of sifting, analysing and winnowing the extensive collection of data helps reduce it to a small set of themes that then lend themselves to a final narrative. Bearing in mind Ragin's belief (1987) that whereas quantitative researchers work with a few variables and many cases, qualitative researchers rely on a few cases and many variables, I decided to concentrate on a small number of case studies. Using the case study Gomm states "allows researchers to retain the holistic and meaningful characteristics of real life events"(Gomm, 2000, p.24). Stake (1998) contends that "a case study is both the process of learning about the case and the product of our learning" (Stake, 1998, p.87). So, I believed this approach would help me to understand and crystallise the learning and the "thinking about thinking" with digital technologies that the EM learning community have engaged with to date.

### *The Case Studies*

The Empowering Minds teachers had one thing in common: they all volunteered their participation in the project. On the other hand, they all brought very different backgrounds and experiences with them. The group was typical of the general teacher population, in that they ranged widely in age (mid-20's to late 50's) and in teaching experience (from one to 25+ years). The EM teachers came from a wide variety of school contexts, including very small rural schools, inner-city disadvantaged schools, large urban advantaged schools, and "special needs" classes within schools. Their students ranged in age from six to 13 years old and were organised in single-grade, dual-grade and multi-grade classrooms. Some of the children were in "special needs" units and were integrated into mainstream classrooms for a few hours each day. Because I aimed for a balance between experienced and inexperienced users of digital technologies in classrooms, and more men answered the "experienced" description, I ended up with more men in the EM population than would be typical of a random assortment of teachers.

As much as I wanted to describe each teacher's unique set of experiences and their engagement over the lifetime of the project to date, I knew such a task was unrealistic for as Stake (1998) states, "many a researcher would like to tell the whole story but of course cannot; the whole story exceeds anyone's knowing, anyone's telling" (Stake, 1998, p.94). Furthermore, it would not effectively capture the full range of the group's exciting learning experiences. So I decided to develop a framework for describing a broad range of teachers' conceptualisations of learning as they embarked on the project, and then tracing the changes and developments in their understanding over time. Initially, I based this framework on the three interconnected elements of Knowledge, Learning and Digital Technologies as the tools of society (See Figure 14).

*Figure 14:* Framework displaying interconnected elements of Knowledge, Learning and Digital Technologies




However, this model would not detect and describe shifts in a teacher's experiences or their thinking over time. Nor would it make immediately obvious any philosophical understandings underpinning a particular teacher's conceptualisation of learning, or map positive or negative attitude towards using digital technologies. And it wouldn't indicate which teachers would make good candidates for case studies.

Then, while Seymour Papert and I discussed how best to select the teacher case studies, this idea emerged: why not use a framework along two dimensions –conceptualisation of learning, and fluency with digital technologies?

With this framework, I would be able to collapse the learning and knowledge elements of the original framework into one dimension, as everyone's conceptualisation of learning is dependent on what we believe knowledge is. Using this simple axial framework, I would be able to place every teacher along each axis, to depict their learning philosophy and experience level with digital technologies (See Figure 15). The further along on the positive digital technologies axis teachers are, the more technically fluent they are and vice versa. Similarly, the further along the positive learning axis, the more Constructionist is the teacher's approach to learning. Conversely, the further a teacher is from the centre on the negative learning axis, the closer the teacher is to the instructionist or behaviouristic conceptualisation of learning. These teachers with an instructionist conceptualisation of learning are often referred to as "traditional" teachers. Their teaching fits the descriptors Brooks and Brooks (1993) outline as characteristic of a traditional classroom:

- Curriculum is presented part-to-whole with emphasis on basic skills.
- Strict adherence to fixed curriculum is highly valued.
- Curricular activities rely heavily on textbooks and workbooks.
- Students are viewed as blank slates onto which information is etched by the teacher.
- Teachers behave in a didactic manner, disseminating information to students.
- Teachers seek correct answers to validate student learning.
- Students primarily work alone

(Brooks & Brooks, 1993, p.17).

In contrast to the traditional teacher, a constructivist teacher displays the following behaviours:

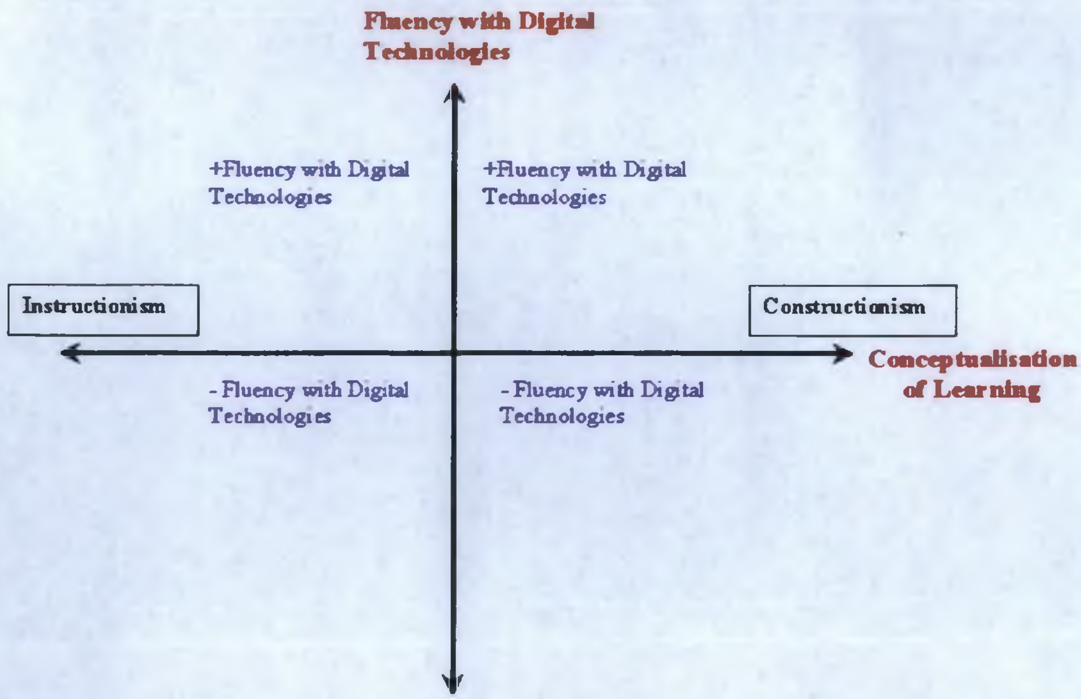
- Encourages and accepts student autonomy and initiative
- Uses raw data and primary sources, along with manipulative, interactive and physical materials
- Uses cognitive terminology such as "classify", "analyse", "predict" and "create" when framing tasks

- Allows student responses to drive lessons, shift instructional strategies and alter content
- Inquires about students' understandings of concepts before sharing their own understanding of those concepts
- Encourages students to engage in dialogue, both with the teacher and with one another
- Encourages student enquiry by asking thoughtful, open-ended questions of each other
- Seeks elaboration of students' initial responses
- Engages students in experiences that might engender contradictions to their initial hypotheses and then encourages discussion
- Allows wait time after posing questions
- Provides time for students to construct relationships and create metaphors
- Nurtures students' natural curiosity through frequent use of the learning cycle model

(adapted from Brooks and Brooks, 1993, pp.103-118)

By conceptualising the framework in this way, I would be able to describe where each teacher was at the beginning of the project, then trace, over time, any changes or shifts in thinking or behaviour.

*Figure 15:* Axial Framework to illustrate a teacher's conceptualisation of learning and fluency with digital technologies




By studying one teacher from each quadrant of this axial framework, I hoped to illustrate the ways the EM experience impacted the learning of teachers across the full spectrum of background and experience. I based my choice of one teacher per quadrant on the premise that I would be able to develop a richer, more textured narrative of their development if I kept the number of case studies small. In order that the teachers selected would be reflect a broad spectrum of backgrounds, school contexts, conceptualisations of learning, and technological fluencies, I considered my choices very carefully.

The most authoritative studies of teachers' career experiences (Sikes et al. 1985; Huberman, 1989 / 1993 / 1995; Fessler and Christensen 1992) suggest that teachers pass through five broad phases (see Table 6 below).

Table 6: *Broad Phases of a Teacher's Career*

| **BROAD PHASES OF A TEACHER'S CAREER** | |
|---|---|
| Phase 1 | Launching a career: initial commitment (easy or painful beginnings). |
| Phase 2 | Stabilisation: find commitment (consolidation, emancipation, integration into peer group). |
| Phase 3 | New Challenges, new concerns (experimentation, responsibility, consternation). |
| Phase 4 | Reaching a professional plateau (sense of mortality, stop striving for promotion, enjoy or stagnate) |
| Phase 5 | The final phase (increased concern with pupil learning and increasing pursuit of outside interests, disenchantment, contraction of professional activity and interest). |

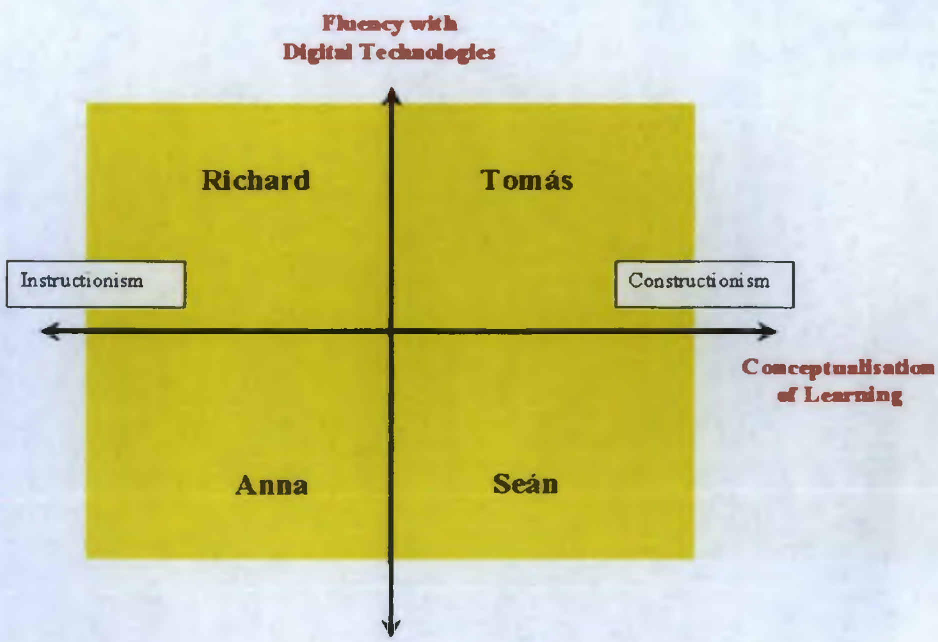
(adapted from Day & Sachs, 2004, p.11)

It must be acknowledged however that this development during a teacher's career should be described as "a process rather than a successive series of punctual events" (Huberman, 1993, p.4). Indeed, "for some this process may appear to be linear, but for others there are stages, regressions, dead-ends and unpredictable changes of direction sparked by new realisations – in short, discontinuities" (Huberman, 1993, p.4). The fact that some "typical sequences" (Huberman, 1993, p.4) can be found does not mean that all teachers pass through each stage. However, having some indication of the stages that teachers typically pass through was very constructive in helping decide what teachers to select for the case studies. Anticipating criticism that the teachers selected for the case studies were still forming their conceptualisations of learning and were perhaps more open to changing their classroom practice, I decided to focus on those who had more than fifteen years' teaching experience (See Table 7 and Figure 16 below) and were perhaps located in phase four of their career as outlined above. This is a phase that typically "occurs at mid-career, generally between the ages of 35 and 50 or between the fifteenth and twenty fifth year of teaching" (Huberman, 1993, p.8). Many would agree with Huberman (1993), that "after 15-20 years one has seen almost every contingency in the classroom and has worked up responses to most unexpected situations" (Huberman, 1993, p.16). Several empirical studies (Adams, 1982; Sikes, 1985 and Prick, 1986) describe it as a stage when the individual explicitly draws up a balance sheet of their professional lives up to now, with some teachers perhaps realising with regret that after 15 – 20 years teaching the number of career options have retracted. So teachers who have reached this "professional plateau" may prove to be those who may embrace new ideas with enthusiasm and enjoyment or perhaps be the most resistant to change either as a result of bitterness, complacency or apathy.

Table 7: *Characteristics of the four teachers selected for the case studies*

| NAME | TEACHING EXPERIENCE | SCHOOL CONTEXT | TECHNOLOGICAL FLUENCY | CONCEPTUALISATION OF LEARNING |
|---|---|---|---|---|
| *Seán* | 20+ years | Disadvantaged, Special Needs Class, All boys | Low | Constructivist |
| *Anna* | 20+ years | Medium sized, semi-rural | Low | Traditional |
| *Richard* | 20+ years | Large, urban, advantaged | High | Traditional |
| *Tomás* | 20+ years | Small (2 teacher) Rural | High | Constructivist |

*Figure 16:* Teachers selected for case studies



I chose to write the case studies from an ethnographic perspective in order to draw a portrait of the ways very different teachers grappled with expressive computational materials and learned to become co-learners with their students – and the ways these efforts contributed to the formation of a culture of "learning how to learn". Every teacher in the study can be considered a case in that it is a bounded system and that this boundedness and the behaviour patterns of the system are the key factors in understanding the case (Stake 1988, cited in Denzin & Lincoln, 1998, p.95). Each case study, as a result, "is an exploration of a 'bounded system' [bounded by time and place]... through detailed in-depth data collection involving multiple sources of information rich in context" (Creswell 1998, p. 61). My case study information sources included:

- Observations – field notes from participant observations
- Interviews – Semi-structured, open-ended taped and transcribed
- Documents – teacher journals, email, web pages
- Audio visual materials – photographs, video, photos,

In order to place each case study fully in context, I include background details about each teacher at the beginning of each case study. Rather than give a detailed chronological description of this teacher's participation and level of engagement with all of the activities of the Empowering Minds group, I highlight particular events that situate each within a social context by providing detailed information about the setting or historical context. I interpret the meaning of these particular events and I situate that meaning in the context of the larger literature.

I found certain events particularly radical and cathartic inducing profound changes in pupils and teachers alike. For many, they represented a turning point in development, some pupils showing hidden, unsuspected talents or abilities; and some teachers professed they would "never be the same again". Woods terms these events

> critical in the sense of crucial, key and momentous rather than being problematic ... These events are characterised by outstanding advance in a number of ways – attitudes towards learning, understanding of the self, relationships with others ...[and] are critical for teacher change having an important preservation and confirmatory function for teachers." (Woods 1993, pp. viii, 2)

However I must acknowledge that many of these "events" (Woods, 1993) or "incidents" may at first appear "to be 'typical' rather than 'critical' ... but are rendered critical through analysis. ...The critical incident is created by seeing the incident as an example of a category in a wider, usually social context" (Tripp 1993, p.25).

In the next chapter, I present a "within-case-analysis" (i.e., a detailed description of each case, and of the themes within it) of each of the four teachers. In addition to developing the richest possible texture and greatest coverage of teacher types and contexts, I chose a small number of representative case studies on the premise "that the unique case helps us understand the more typical cases" (Stake, 1988, p. 261), and that "practitioners can learn from a case study even if the circumstances of the case do not match those of their own situation" (Erickson, 1986, p. 153; Stake, 1988). We can gain insight from the particulars of a case because "highly descriptive accounts of practice allow a reader to put him or herself in the place of those in the account" (Kilbourn, 1990, p.113). By presenting alternative perspectives of the possibilities when one begins to question what being digital can mean in learning, I enable my readers to identify with the teachers in the case studies, and to relate their experiences to their own beliefs and assumptions about learning.

By describing settings and the participants' experiences in rich detail using "thick" descriptions, I hope to enable readers to transfer information to their own settings (Erlandson et al., 1993; Lincoln & Guba, 1985; Merriam, 1988) and to determine whether they can do so "because of shared characteristics" (Erlandson et al., 1993, p. 32). My challenge has been "to provide sufficient contextual data to enable the reader to reconstruct the substantive issue and thus participate in the meaning making process" (Sugrue 1997, p. 42). I hope that these case studies will expand the potential audience well beyond practitioners in the classroom, so others may enter the debate about what being digital in learning can mean.

## *Standards of Quality and Verification*

Because this type of research is particularly vulnerable to charges of "lack of rigor" I made sure to counteract that sort of criticism by spending sufficient time in the field, and by ensuring the body of Empowering Minds evidence I used as data was extensive (Erickson, 1986). In terms of rigor, issues of trustworthiness and dependability were met through systematic data collection methods and a rigorous approach to data analysis where multiple data sources facilitated triangulation. Also, I enhanced the quality of the analysis and ensured trustworthiness of the study by incorporating peer review as well as participants' review of each of the case studies.

The process of triangulation involved using multiple sources and "checking out the consistency of findings generated by different data-collection methods" (Patton, 1990, p.464) to provide corroborating evidence that would shed light on a theme or perspective (Ely et al., 1991; Erlandson et al., 1993; Glesne & Peshkin, 1992; Lincoln & Guba 1985; Merriam, 1988; Miles & Huberman 1994; Patton, 1980, 1990; Yin 2003). The most important advantage presented by using multiple sources of evidence is the development of converging lines of inquiry. Thus, as Yin (2003) suggests, "any finding or conclusion in a case study is likely to be much more convincing and accurate if it is based on several different sources of information, following a corroboratory mode" (Yin, 2003, p.98)

Peer review or debriefing also provided an external check of the research process (Ely et al., 1991; Erlandson et al 1993; Glesne & Peshkin, 1992; Lincoln & Guba 1985; Merriam, 1988) in much the same way as interrater reliability serves in quantitative research. The role of the peer debriefer is very much that of "devil's advocate" (Lincoln & Guba, 1985) who keeps the researcher honest by asking the hard questions about methods, meanings and interpretations. During the development of each of the case studies a number of colleagues acted as peer debriefers. Two of these debriefers were members of the EM community (Glorianna Davenport and Fred Martin) while another was a faculty member of the education department of St. Patrick's College (Margaret Leahy) who was conversant with the constructionist principles and computational materials we were using but was not a member of the EM community.

The final procedure followed related to ensuring the accuracy and overall quality of the study was to have the draft case studies reviewed by each of teachers who was the subject of the case study. In agreement with Yin (2003, p.159) I believe that this review process was more than a matter of professional courtesy but as a way of corroborating the essential facts and evidence presented in each case study narrative (Schatzmn & Strauss, 1973, p. 134). After they had reviewed the drafts I disguised the teachers' identities so that only they will know the true identities of those presented in each case study.

Qualitative researchers also are particularly vulnerable to question of that thorny issue, validity. Fetterman (1989, p.46) contends that "working with people day in and day out, for long periods of time is what gives ethnographic research its validity and vitality". Wolcott (1990a, p.136) suggests that "validity neither guides nor informs" his work because ultimately, he is trying to understand rather than to convince and he asserts that conventional notions of validity distracts from his work of understanding what is really going on. For the purposes of this study, I am in agreement with Wolcott: as I was engaged in a process of trying to understanding how people – particularly teachers – come to "learn how to learn". I did not want to be overly concerned with validating the work, in the traditional sense. For me, validity is best expressed by Richardson's (1994, p.522) metaphorical description in which she challenges the traditional image of "validity" as a rigid, fixed, two-dimensional object very different from her central image of the crystal that

> combines symmetry, substances, transmutations, multi-dimensionalities and angles of approach. Crystals grow, change, alter but are not amorphous. Crystals are prisms that reflect externalities and refract within themselves, creating different colours, patterns, arrays, casting off in different directions. What we see depends on our angle of repose...Crystallisation, without losing structure, deconstructs the traditional idea of 'validity' ... crystallisation provides us with a deepened, complex, thoroughly partial understanding of the topic. Paradoxically we know more and doubt what we know (p.522).

For me, "validity" meant my effort to ensure that I wrote an honest interpretation and representation of the learning experiences that others within the Empowering Minds group and I engaged in as we tried to understand learning and what being digital can mean in learning. While helping us know more about how teachers learn, these narratives should also prompt us to identify and interrogate our existing beliefs and assumptions about learning and the place of digital technologies within our schools and classrooms.

## ***Writing the Narrative***

Acutely aware that the way one presents findings depends on the audience with whom one is communicating (Giorgi, 1985), I wrote this dissertation for anyone with an interest in learning or understanding what being digital can mean in learning. So I deliberately decided to employ "a writing style that is personal, familiar, perhaps 'up-close,' highly readable, friendly and applied for a broad audience" (Cresswell, 1998, p.170).

In each case study, I carefully chose salient quotes and vignettes from field notes, interviews and observations to include a level of detail that makes the work come alive for its reader. Writing "lushly" (Goffman, 1989, p. 131) or "thickly" (Denzin, 1989b), and using descriptions that create "verisimilitude" (Richardson, 1994, p. 521) are strategies that help reveal the progression of layers in contextual meaning, and strengthen interpretations of data (Bogdan & Biklen, 1992; Lincoln & Guba, 1985; Erickson 1986; Goetz & LeCompte, 1984). "Thick" descriptions take into account the context of an activity or behaviour (Ryle, 1971; Geertz, 1973). Falbel (1989 p.23) explains the goals of more detailed context:

> The aim of thick description is not to establish cause and effect but to explain an event by placing it in an informed context...to gain a better understanding of *what's going on* beneath the surface of an activity or piece of behaviour without reducing it ...to some sort of mechanism

And discussing the vitality of "thick" rather than "thin" descriptions Denzin (1989, p. 83) suggests that the narrative "present detail, context, emotion and the webs of social relationships [which] evokes emotionality and self-feelings " in an attempt to capture "the layers of significance that lie beneath observable action" (Falbel 1989 p.59). Writing "thickly" also ensures that the "voices, feelings, actions and meanings of interacting individuals are heard" (Denzin, 1989, p83). Because dialogue is an integral element of "thick" description, I have chosen to use the teachers' words rather than my own wherever possible, and with the greatest respect to the teachers. I aim for these "thick" descriptions to evoke in readers feelings that they have experienced, themselves, or perhaps can experience from the events I describe (Denzin 1989b). My strategy is precisely that described by Sugrue: "Instead of being presented with findings the audience is invited to come to terms with the issues raised. Readers are drawn into the dialogue through their own reflexive capacities" (1997, pp. 41-42).

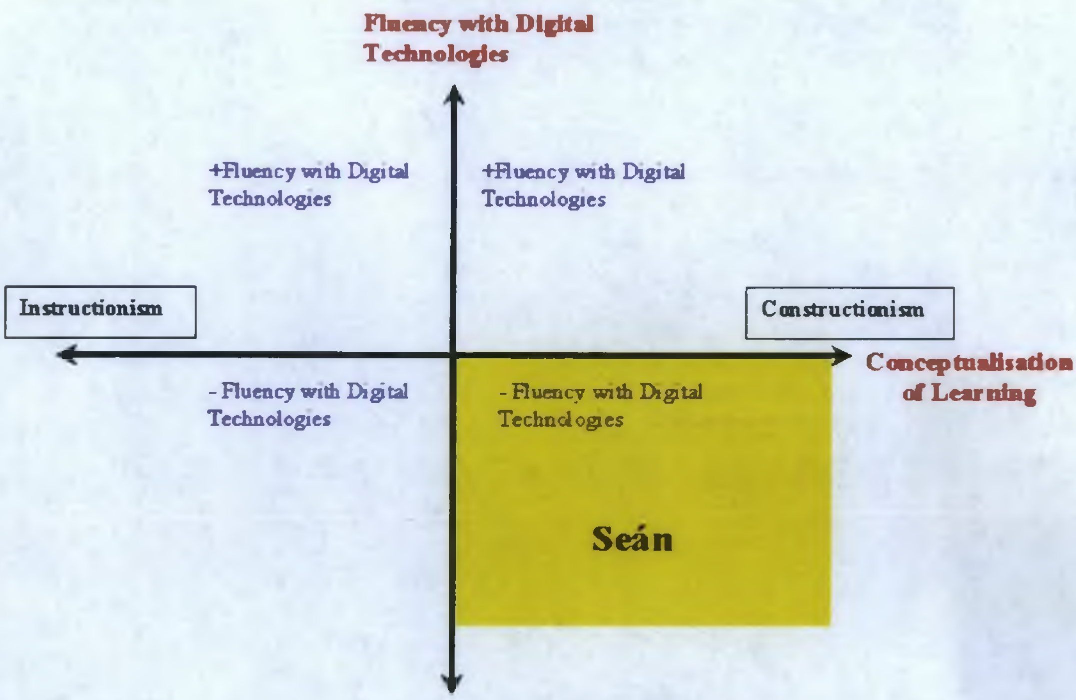
The reader who is drawn into the worlds of the Empowering Minds group and the contexts in which each of these teachers was situated may gain an understanding of the complexities of learning and the level of sustained intervention we must sustain before we can hope to see any significant change either, in the ways learning is understood or in a critical realisation of what being digital means in learning.

# Chapter Five
# TEACHERS' VOICES

## Case Study 1: Seán
*The Reflective Tinkerer*

> Above all, even beyond the love of knowledge, is this principle: If you love what you learn, you'll get to love yourself more. And this has to be the goal of education that each individual will come out with a sense of personal self-respect, empowerment, and love for oneself, because from that grows all other loves: for people, for knowledge, for the society in which you live (Papert, 1990, p.13).

*Figure 17:* Seán - Open to New Learning, New to Digital Learning




### *Introducing Seán*

A gentle, caring soft-spoken individual, highly tactile and a self-described "tinkerer," Seán had been teaching for 21 years when he joined the project in its second year. Seán loves the challenge of fixing something and getting it to work, and he is regarded as the "in-house handyman" at school.

Seán's all-boys' school is in a disadvantaged area on the north side of Dublin City, surrounded by high-rise public housing known locally as "The Towers." Many children at Seán's school come from households gravely stressed by poverty, long-term unemployment, drugs and alcohol abuse, absent parents, and family members imprisoned.

After 17 years in mainstream teaching, Seán decided to move into the area of special needs teaching. From the outset, he was acutely aware that the special class at his school was marginalised in terms of day-to-day activities and culture. So ingrained was this hierarchy that a senior teacher actually took Seán aside, asked him whether he realised he would be setting him self apart by teaching the special class, and predicted that Seán would be very lonely as he would have little or no contact with other teachers and children. His colleague's "advice" backfired, though, as Seán was upset and offended, and all the more determined to redress the situation any way he could.

The special class, boys aged 10 to 13 years, ostensibly had "failed" within the existing educational system. But Seán often suspected it was the other way round: that the system had failed these children. He was constantly on the lookout for ways to awaken interest in learning: "I'm always looking for other projects that [I] think will appeal to the kids. Most of the time I'm trying to motivate them because an ordinary approach . . . or the experience the kids have had in school has turned them off learning" (Interview, July 2002).

He also concentrated on building strong relationships with these boys, encouraging independence and improving their self-esteem. Indeed, when I first visited the school and met Seán's boys in the "Senior Learning Resource" class as they first started to work with the computational materials (September 2000), I was impressed by how chatty and open they were with me, and the range of day-to-day activities they were responsible for—they took care of all audio visual equipment in the school, for instance. They delivered what each teacher requested each morning, and returned the equipment to the strong-room each evening. When I commented to Seán about how responsible his students were, he said he was continually looking for ways to support them, as he believes, along with Humphreys (1993) "that giving responsibility to students and believing in their ability are powerful boosts to their self esteem" (Humphreys, 1993, p.24).

## *Seán's History With Computers*

He did not have a great deal of experience in using digital technologies, but Seán was open to their possibilities in a learning environment. But he felt reassured that others were as uneasy as he was. This encouraged him to continue and return each day to the workshop:

> Having the opportunity at the end of the day to talk, we could hear other people say how . . . uncomfortable they felt as well. So it made you feel that you weren't just on your own. So that was very important when we went back the following day (Interview July 2002).

## How Seán and Empowering Minds Came Together

In the year before he joined EM, Seán completed a year-long, full-time postgraduate diploma with the Special Education department at St Patrick's College. During this year, as a result of his friendship with Sean (another member of the diploma class who I was supervising for his major assignment for the special education course), Seán first came in contact with the computational materials and ideas we were working with in the Empowering Minds project. His discussions with Sean about Seymour Papert's writings and their applications to children with special needs motivated Seán to come along to the project's first big open day which was held at the college in April 2000.

Although he was already intrigued by EM, the thinking behind it, and the computational materials involved, Seán characteristically took his time and weighed his decision carefully. At the open day, he talked extensively with the teachers and children about their work of the past year. The following week, he came to me, expressed his deep interest, and asked what he needed to do if his school were selected. I explained that we would need the principal's support and at least one other teacher in the school to work with the materials—if possible, a female teacher working with a different age group. He immediately replied he thought these were very important prerequisites for diversity and richness, but would have to think carefully about whom to ask to be his partner (Field notes, April 2000).

## Choice of Partner

Seán took his time, deliberating his choice of partner. His friend Donal, the school's computer resource teacher, was an obvious choice: he and Seán had worked together long enough (ten years) to know they shared educational interests and philosophies, and Donal, unlike Seán, knew a lot about computers (though he didn't claim to be an expert), so he would be a natural ally when the computational materials were introduced. Donal was open to learning about new technologies and was confident that if Seán thought this was a good idea he was willing to go along with it (conversation at workshop August 2000; Interview September 2000; Interview December 2002).

However, Donal was not responsible for a class grouping as he was the computer resource teacher. So Seán and Donal had to search for another staff member to work with them, as they needed two teachers who had their own class groups. Donal suggested Lorraine, a new teacher in the school, who met all the project-suggested criteria: She was female, teaching a junior class (children aged nine years), knew a little bit about computers, having learnt Logo while an undergraduate. Seán did not know Lorraine well as he had been away from school the previous year doing the fulltime postgraduate course. But he went along with Donal's recommendation, as she appeared to be the ideal candidate and when approached gladly agreed to devote extra time to the project.

With the team selected, Seán talked to the principal in depth about the project. He explained the materials that would be supplied, the support system that was promised but also indicated the level of commitment he expected to require from the school because he knew that

> It very much depends on the principal. . . . That's a big factor in the school, how it's led from the top down. You can do so much yourself but how it's organised in the school and how people feel about themselves is a very, very important factor." (Interview July 2002)

From the beginning, Seán's principal, who also had previously been a special-education teacher, was and still is very supportive. Seán believes the principal understood and empathised with Seán's intuitions that this project would be very beneficial for the boys in the special learning resource class (conversation, February 2003).

## *Seán in the EM Workshops*

### *First Workshop*

#### *Anxiety levels.*

Like all the other EM teachers, Seán was used to highly structured, content-driven inservice presentations, conducted by a "presenter" or "expert": "You'd go in as a teacher, and be told, 'Here's the structure—*you* do it.'" But at the EM workshop (August, 2000) "there we were with the materials, and what do we do? And you're kind of looking around at people. . . . And I found that strange initially"(Interview, July 2002).

What he—and all his colleagues, that first day—found "strange" was EM's evident lack of structure: "When we went in there the first day, we were just kind of given the materials, without any kind of plan"(Interview, July 2002).

During the workshop, Seán told me that at first, he was more than a little anxious. At times he admits he even felt "under threat," being in a situation where he wasn't being told what he should do and was continually asking himself, "What's going on here?" (Field notes, conversation with Seán, August 2000). He later admitted that for

> The first few days I was kind of worried because we didn't know what was going to happen from session to session. We didn't know what was going to be the next assignment, let's say, or project (Interview July 2002).

But Seán did not perceive the learning as a threat to his self-organisation, which could have made him go rigid and resist the learning environment (Rogers, 1969). Strange though he found it, Seán was open to giving the new approach a chance and enthusiastically began working with the materials. Eventually, he realised that rather than being unstructured, the workshop was in fact self-structuring (Field notes, cluster meeting, December 2000). The participants were setting their own learning goals as they built their own chosen projects using the computational materials. Seán, Lorraine, and Donal began to build a dragon; their goal was to have the tail wag back and forth as the dragon moved forward technologies (See Figure 18). As learners, they were actively involved in the learning process, so their experiences were meaningful and their motivation levels rose accordingly (Ruopp, 1993; Thompson et al., 1992, pp.11, 68; Thornburg, 1994, pp.24-25).

*Figure 18:* Tail-wagging Dragon by Seán, Donal and Lorraine, August 2000

Seán was so absorbed that, right from the start, he brought along his analogue video recorder to capture his experience, as he wanted to share it with the boys when school resumed the following week. He knew that when he introduced these computational materials into his classroom, he would be radically altering the traditional pattern of "teachers teach, students learn and administrators manage" (Kleine-Kracht ,1993, p.393). He wanted to be able to show the boys that the teachers too were only beginning to learn about these materials and that they would be relying on the boys to help them out to learn how the materials could be used. Seán already was comfortable sharing learner status with his students so, from the outset, he saw this project as a joint learning venture between teachers and students. There would no longer be "a hierarchy of who-knows-more-than-someone-else, but rather the need for everyone to contribute." Everyone would be learners "questioning, investigating and seeking solutions"(Kleine-Kracht, 1993, p.393).

*Feeling threatened.*

We had thought that having the first group of nine teachers at this workshop (August 2000) would help and encourage the new teachers. . The original group had impressed strongly on us that having John Bilotta (a teacher and technology co-ordinator from Rhode Island) work with them at the first summer workshop (August 1999) had given them great encouragement that this new way of working was possible and immensely worthwhile for both teachers and children. In addition to trying to cope with working with the unfamiliar computational materials in a seemingly "unstructured" environment, Seán commented that, at first, he was actually made uneasy by these experienced teachers: "not knowing the group, . . . you wonder where you are fitting in, in relation to the group" (Interview July 2002). But by the third day, he was more settled as he got to know the other participants in the group: "[T]here was a lot in the first few days, but I got a lot more comfortable and a lot happier with it" (Interview July 2002).

So although he had "felt threatened . . . that some people that were there had already done it before," as the week went on, he realised that these experienced teachers were in fact a great asset. He could go to them for help or advise, and he noticed that a working relationship developed across the experienced and inexperienced groupings: "As the week went on, you realised, 'Hold on there for a second! . . . We're all here together!,' and working as a group developed" (Interview July 2002).

With the support of a community, Seán found himself in a very powerful learning environment, as he began to realise that "other people are the greatest source of alternative views needed to stimulate new learning" (von Glasersfeld, 1989).

### *"No Man is an island": Working With a Partner*

Two things that Seán identified as instrumental in helping him settle to work with the materials were (1) having a good friend from school with him as a partner, and (2) participating in frequent reflective group discussions:

> We worked together until toward the end of the week. As the week went on, I got to know some other people, and we worked well together, and shared our views. . . . There was a great sharing of ideas towards the end of the week (Interview, July 2002).

Most of the new teachers relied on the other teachers from their own school before they felt comfortable enough to branch out and work with others. Coming to grips with the materials was for many a daunting enough task without having to cope with developing new social relationships as well. Finding their comfort level took longer for some teachers but we encouraged them whenever possible to look upon the others in the group as "flexible resources" (Rogers 1969) that they could use and rely on. A range of studies (Zetlin et. al. 1998; Mc Laughlin and Talbert, 1993) has demonstrated that a supportive community encourages the sharing and dialogue necessary to promote trust and risk-taking. The majority of the teachers realised how comfortable working with a friend was for them, as they had felt safe (Maslow, 1972).

### *Seán in Discussion*

Hearing other people's opinions and ideas was important to Seán, as they helped answer questions or clarify doubts he may have been experiencing while also providing new ideas to think about (Von Glasersfeld, 1989): "[H]aving an opportunity at the end of the day to discuss what we were at, kind of reassured me (Interview July 2002).

Being able to voice his own opinions and ask questions was equally important to Seán as he tried to understand the Constructionist approach to learning and what was possible using these computational materials. The development of this open, respectful ethos across the members of the EM community was vitally important to combat the ersatz "interactional congeniality" and "surface friendliness" that can impede individuals from examining their personal beliefs or practice (Grossman and Wineburg, 2001).

The group discussions were instrumental in Seán getting to know the others' opinions and ideas. This helped him relate better to these people as he had a greater understanding of what informed their actions and he began to feel comfortable sharing his thoughts and ideas with them. Once he was comfortable, he was able to engage more in learning with the computational materials because despite his reserved manner, he's an eager questioner whose ego never gets in his way when wants to learn:

> I'm always open to asking for advice. That's always been my approach. Much of what I've learned about teaching has been in the school. From the moment I went into the school, I've been like that. . . . I'll always ask if there is something that I don't know (Interview July 2002).

Once confident, Seán constantly asked questions and sought advice from others. These opportunities for reflective thinking and engaging in collaborative inquiry laid the foundations for the development of the skills and confidence to support teacher change (Darling-Hammond 1996; Hamilton & Richardson 1995).

### *Upon Reflection*

Overall, Seán deliberates and thinks deeply. Upon reflection, things begin to crystallise for him:

> It was only afterwards [the first workshop] I realised . . . going in and telling people, 'This is how you do A, B and C,' that you're not allowing for any creativity. You're not allowing people just to sit back and think about the material (Interview July 2002).

In response to questions, Seán was likely to respond "Can I think about that and get back to you?"— which he would then faithfully do. He kept a little notebook as "a useful way of going back over" the experiences of the day (Field notes, summer workshop, August 2000). Often when he is grappling with an issue and is talking in a one-on-one situation (e.g., after classroom visits, casual visits to my office), he seems to think aloud, using one's input to help him come to grips with his thoughts.

## *Seán Back at School*

### *Affirmation & New Beginnings*

Upon reflection Seán realised that prior to his involvement with the project, Seán felt his style of teaching was Constructivist in nature. The first workshop and subsequent engagement with the project reaffirmed his basic ideology and encouraged him to continue to work in this way with the children in his care each day.

> I suppose I could say . . . that . . . Constructivism would characterise a lot of my teaching. But during the workshop it just gave me, it reaffirmed my kind of approach to learning. So I kind of felt going in, "Yes!"—you know, "This is a good way." (Interview, July 2002)

Reaffirmed in his convictions about Constructivist learning, Seán was eager to get back to school with the new computational materials:

> I couldn't wait to try it, particularly with the class I have. . . . I'd been searching around for other ideas in the school that might work. I thought, "Yes! This could work!" And I couldn't wait to see how different fellas would react as well. [They] had failed in the ordinary English and writing . . . and this was going to be a new way of learning. So I really was looking forward to the new year with the materials (Interview July 2002).

*The "dummies."*

Lack of self-esteem Seán believes was the root cause of many of the problems that the children in his integrated special class were presenting with in school. Before Seán became involved with Empowering Minds, his boys had little experience of "the feeling of being lovable and the feeling of being capable" (Humphreys, 1993, p. 3), the two dimensions central to self-esteem, defined by Reasoner as "the degree to which people feel worthy, capable, significant and effective (1992, p. 12). Seán intended to break his suburban, disadvantaged boys' "cycle of failure" so they would feel better about themselves and more hopeful about their lives, and they would reengage with learning (Conversation, May 2000).

Seán knew that mainstream teachers' and peers' view of his students was crucial to their self-esteem. As evidenced by his colleague's "caution" to Seán against switching to the special class, the school generally regarded these children as "very different" and not as capable as the mainstream children. Nobody liked to be part of the special class unit, as its members were classified as "dummies" by the rest of the school. No wonder, then, that every boy within the unit had a very poor self-image and lacked self-esteem.

*Distributed expertise.*

When he returned to the classroom, Seán set up his own Atelier-style workshop (Kuhn, 2001, p. 5) and encouraged the boys to share ideas about their constructions and to critique each other's work and designs. He wanted to provide opportunities that would enable the boys to talk about their thinking as "it is the thinking about the problem that fosters learning. So does talking about the problems or showing them to someone else" (Papert 1996, p.12). But he expected that this new way of working might prove to be very difficult as these boys generally displayed behavioural problems. They were often very antagonistic towards one another and found it very difficult to co-operate on even the smallest of tasks.

So he was surprised to discover when he introduced the computational materials that collaboration developed naturally. The boys began to look to each others' building projects for ideas, and some boys began to emerge as competent builders who were willing and able to help the others. He encouraged the boys to keep records of their work as they developed it. Using photographs and drawings and sometimes text, the boys kept accounts of their thinking over time—the problems, successes and design changes. Working like this, Seán believed, his students would "get a sense of the way in which real designers go about their work, as part of a community of designers" (Resnick and Ocko 1991, p.6) rather than being the receptacles in the traditional classroom scenario that "is based on the model of the pipeline through which knowledge passes from teacher to student" (Papert 1996, p.45).

When you visit his classroom now, "it is common to observe one child tutoring another on programming or a number of children making recommendations for improvements in each other's project designs" (Masters coursework assignment, November 2002). Seán openly tells everyone that "these positive outcomes were not usually present in my class, prior to the LEGO Mindstorms work." (Masters coursework assignment, November 2002)

### *David's Crane.*

When Seán and his students got going with the computational materials, the special class soon stopped thinking of themselves as dummies. So did the rest of the school. David is a particularly radiant example of the transformations that began almost immediately:

> [David] had experienced many years of failure in mainstream classes. He had little interest in learning, was difficult to motivate, and his self-esteem was very low. He announced to the principal and myself that he did not like himself, was "no good at anything" and that he was going to leave school. This incident coincided with the arrival of the LEGO Mindstorms materials into our school.
>
> I introduced David to LEGO Mindstorms and, while the rest of the class were learning basic building principles, David constructed an elaborate crane on his own initiative. [See Figure 19, below.] He displayed his

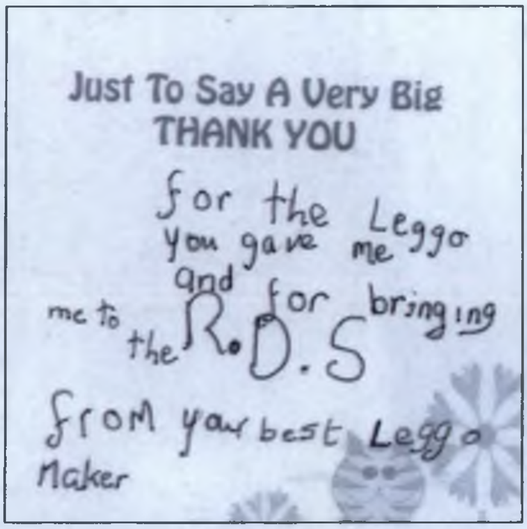
model around the school. This LEGO robotic crane became the stimulus for numerous learning activities and the development of skills that, up until then, David could not or did not want to work on.

He displayed his model at the National Young Scientist Exhibition held in the R.D.S. in January 2001. With the boost to his self-esteem, David became more sociable and confident. He had a new self-respect in the learning community. He was called on regularly to assist boys with LEGO construction, in the mainstream class and in his own class. His reading improved, as he wanted to learn all the programming words and the names of the LEGO parts.

When David left our school last June, he gave me a thank you card. [See Figure 20, below.] His reference to himself as "your best LEGO maker" is indicative of the positive self-image that he now holds of himself. David has moved on to a second level school but he comes back to the school regularly to mentor other pupils, in their LEGO robotic work. Our learning community now extends beyond the walls of the school (Seán's Summer Report 2001).

*Figure 19:* David Tests His Crane Construction

*Figure 20:* David's Letter of Thanks




David is similar to children whom Papert has written about extensively, for "as seen through school tests he appears as an incompetent person: virtually illiterate, devoid of mathematical knowledge—in brief, 'a failure'" (Papert, 2000, p.721).

However, "[David's] life has been turned around as a result of his experience with LEGO Mindstorms" (Seán's summer report, 2001). Rather than leave school as he had threatened to do at the beginning of the school year, he has completed his primary programme and is now attending a second-level school. He returns to Seán's classroom every Wednesday when he has a half-day, and works with the boys in the workshop.

Teachers and boys alike hold David in high regard, and he enjoys his new role as "building consultant."

### *Genuine Partnership*

Before EM, when Seán had tried to establish Constructivist-style learning environments, he still was more in control than the learners of the learning experiences, as he knew the content and had some ideas about the direction the learning might take. But with EM's new computational materials, he did not have "all the answers". For the first time in his teaching career he was going to be genuinely learning alongside the children.

> We were all working together. . . . Kids would ask me how to sort out things, and me having to say "I don't have the answers." I mean, *that* was humbling! That was . . . a difficulty initially. . . . Rather than being up at the desk, you're among the kids, saying "How are we going to sort out this?" So for the kids, it was a new approach as well. The fact that they were showing Teacher how to do something was a new experience for them and for me (Interview, July 2002).

Though Seán found these new experiences "strange initially" even "humbling," "then it was great . . . because you're going in and you're learning new things as well, discovering new things." Seán was so fired up by this new learning with the computational materials that he brought his laptop and the Mindstorms materials "home in the evening [to] . . . try out things, try out new ideas and new approaches" (Interview, July 2002). We had learned from the success of each teacher having a laptop in the first year that having a set of their own materials facilitates teachers' own out-of-class learning. Seán's pleasure in having his own personal materials was making the case that the teachers needed to have the time to engage with learning (Raywid, 1993), to play and experiment with the computational materials.

### *Deeper Relationships*

"I think my relationship improved with the kids—big time," Seán said after his first year in the Empowering Minds learning environment (Interview, July 2002). I visited his classroom when they had been working with the materials for just a short time (November 2000) and I was struck by the easy, respectful, even playful relationship between Seán and the children. Later, he remarked that he had always related well to them, but now he felt the relationship was more honest and equitable, as they experienced "shared learning," and the children were also more in control of their own learning. What Lindeman stresses for adult education is also applicable to younger learners, as Seán's "curriculum [was] built around the students' needs and interests" with experience being "the living textbook" (Lindeman, 1926, pp. 8-9). In choosing their own projects, the children set their own learning agenda, and Seán worked with them. So the learners set the direction of the learning, according to purposes meaningful to them, and Seán organised and made readily available the widest possible range of resources for this learning. He became a participant learner and a flexible resource within the group (Rogers, 1969).

### *"School is where I want to be!": The Confirmation Suit*

From the very earliest days, Seán knew the computational materials had struck a chord. Suddenly, boys who were renowned for attending school on a very erratic basis began to attend on a regular basis.

At a group meeting in May 2001, Seán told us about the transformation of David (the boy who had built the crane in the earlier story) formerly a stubbornly reluctant student, whose mother decided to take him into the city centre one day, to buy new clothes for his upcoming Confirmation ceremony. Normally, David would have been overjoyed at the prospect of missing a whole day of school. But as they waited at the bus stop, he became very agitated and began to insist that he *had* to go to school, as French teachers were coming in to see his work and talk to him about his project. His mother tried to persuade him to forget about school with the promise of some extra treats, but David was not to be dissuaded, and when the bus arrived, he flatly refused to get on it. Dumb-struck, his mother brought him to school, explained why he was so late, and remarked to Seán that she could not fathom this change in her son who, a few months ago, had declared that he was leaving school altogether.

> Three French teachers visited our school today. David was absent despite the fact that he told me the previous day that he would be in to meet them and to show them his crane. At 9.30 a.m. I was informed that David's mother was taking him into town to get him his confirmation clothes. However, at 10.30 a.m. David arrived into the school with his mother – he had pleaded with her to leave the bus stop and bring him over to school because he wanted to show his models to the visitors (Seán's Journal, May 2001).

With evident passion, Seán said this incident alone would have been enough to convince him that he was changing these boys' attitudes and beliefs about learning and their own self-worth: "It's given me a renewed enthusiasm . . . It's something I enjoy doing. So if there's something you enjoy doing you're going to stay with it" (Interview

July 2002). David's shopping boycott indicated a permanent shift in his school attendance, as shown in Table 8, below.

Table 8: *David's attendance records*

| 1999-2000 PRE-EM | TERM 1 JULY-SEPT. | TERM 2 SEPT.-DEC. | TERM 3 JAN.-MARCH | TERM 4 APRIL-JUNE | TOTAL ATTENDANCE |
|---|---|---|---|---|---|
| ***School Days*** | 22 | 49 | 51 | 53 | 175 |
| ***David's attendance*** | 22 | 26 | 37 | 42 | 127 |
| **2000-2001 EM class with Seán** | | | | | |
| ***School Days*** | 20 | 52 | 50 | 52 | 174 |
| **David's attendance** | 12 (60%) | 45 (87%) | 48 (96%) | 47 (100%)** | 152 (+5) |

**The school gives graduating boys their summer holidays a week before end of term, so David in fact had perfect attendance in Term 4

But David wasn't the only one in the special class who couldn't wait to get to school every day. All the boys improved their attendance dramatically. (See Table 9, below.)

Table 9: *Sample attendance records from new students in Seán's classroom*

| 2002-2003 PRE-EM | TERM 1 JULY-SEPT. | TERM 2 SEPT.-DEC. | TERM 3 JAN.-MARCH | TERM 4 APRIL-JUNE | TOTAL ATTENDANCE |
|---|---|---|---|---|---|
| ***School Days*** | 21 | 49 | 55 | 50 | |
| ***David*** | 18 | 40 | 44 | 44 | 81% |
| ***James*** | 18 | 38 | 40 | 40 | 83% |
| ***Brian*** | 19 | 20 | 42 | 42 | 58% |
| **2003-2004 EM class with Seán** | | | | | |
| ***School Days*** | 20 | 54 | *** | *** | |
| ***David*** | 18 | 52 | *** | *** | 95% |
| ***James*** | 16 | 50 | *** | *** | 89% |
| ***Brian*** | 20 | 54 | *** | *** | 100% |

***Figures for Terms 3 & 4 not available at time of writing

Seán constantly remarked upon this phenomenon, for him a concrete sign that the changes in his practice meant school was now more meaningful for these boys. Being able to attribute growth in his students' learning to changes in his classroom practice (Guskey, 1986) energised Seán and gave him renewed confidence to continue working in a Constructionist way, using these new computational materials. And the transformation continues, as the new recruits in Seán's class demonstrate by their dramatically increased attendance (See Table 9 above).

### *Classroom Facelift: Transforming the Learning Environment=Learning Itself*

When the materials arrived and the boys began working with them, they quickly discovered they needed some system for easy, effective storage and retrieval—easily and effectively. They couldn't find pieces they wanted easily and remarked that they getting frustrated, "wasting time, looking for stuff." Seán and the boys discussed ways to arrange the materials and how to store them. Working together, they completely revamped their classroom round the organisation of these new computational materials that the boys value so much. They built shelves, painted them in the bright vibrant colours of the LEGO materials (red, blue, yellow and green), and mounted them on walls around the classroom. They sorted the materials into transparent plastic containers (the boys' idea), so now they can find and put away the LEGO pieces easily and efficiently as they can see at a glance what storage container contains which pieces. They have also built special racking units to accommodate the reference materials for the building materials and books associated with whatever project they are currently working on. The boys take special pride in their reference materials and books as, prior to their engagement with Empowering Minds materials, these resources generally were found in mainstream classrooms, not in a "special" learning classroom.

Problems with batteries for the Programmable Brick led to another building project: they needed a system to ensure a constant supply of charged batteries, rather than discovering they were out just when they had a model ready for testing. Besides remembering to put the chargers on in the evening, they also had health and safety concerns about the trailing wires from the extension leads; they were afraid people might trip over these leads and injure themselves. Coupled with these concerns was the problem of protecting the expensive items (e.g., the RCX itself, the sensors and the motors) and the models from others who used the school after hours. They converted a large, disused wooden cupboard into a specialised storage and charging unit. Seán wired an extension lead with a timer on it for charging the batteries into the cupboard. The shelves inside store models, and appropriately-labelled transparent boxes house the batteries and other important pieces of equipment.

The boys took immense pride in reorganising their classroom around these new computational materials. Remarkably, after nearly four years of use in a school that generally suffers from mistreatment of equipment, none of the computational materials have been broken or have gone missing—testimony to how valuable these materials are to these boys.

### *Further Transformations: Specialised Workshop*

As the boys' projects became more elaborate and they began incorporating backdrops and scenarios for their models, Seán and the boys decided to renovate a disused storeroom next to their classroom, to use as a workshop all day and then lock up in the evening (See Figures 21 and 22, below).

*Figure 21:* The boys converting the old store room into their workshop

*Figure 22:* The finished workshop

They could leave models out on the benches overnight, and wouldn't need to pack everything away each evening. They devoted months of preparation and hard work to clearing the room, planning the new layout, installing workbenches and shelving units, putting down new floor covering and painting everything. With Seán's help (when requested), the boys did all project planning, costing, constructing, and painting. When it was ready, they held a formal opening of this new workspace to officially celebrate their achievement. Now, these formerly feisty boys use their workshop constantly, usually without direct supervision; they requiring Seán's help only to consult or discuss something about their projects.

Here we see just one of many examples in Seán's classroom of Dewey's educational principles in action. The children's experiences are the key starting point of the educational process while democracy, continuity and interaction inform the process. Seán is very proud of this new workshop as the concrete embodiment of these boys' potential, and it demonstrates to others that he was right to believe that these boys, who had "failed in the system," would gain ownership and control over their own learning and demonstrate their potential.

### *Interest from Home*

Seán's students had very little connection between their home lives and their school lives. Parents or other family members rarely came to the school unsolicited, as news from there was usually about their son's "bad behaviour" or "poor academic performance." Seán also knew that many of the parents themselves were unhappy at school and did not regard it as a welcoming or pleasant environment. Without parental interest and encouragement, the boys were further alienated from school activities and felt bad about themselves.

But soon after the boys starting using the computational materials, Seán began to notice that their friends and younger siblings began to drop by his classroom frequently to see the "great stuff" they were making. Some of the parents made a point of calling in at the classroom when collecting their younger children, as their sons had talked so much about what they were building and had begged them to come and see their models. The parents were thrilled, proud of their sons' work, delighted to celebrate something their sons did in school, all of which enhanced their own and their sons' self-worth.

Seán arranged a school exhibition, so the children could demonstrate and explain their work to the wider community. Sharing their work in this way not only cemented greater home/school links but also improved "the child's relationship with his work, turning it into something shareable and therefore more positive" (Papert, 1976, p. 7). Attendance at the exhibition was unprecedented and the parents, teachers and other children were

> amazed at the children's ability to articulate the process involved in constructing their models and at the huge amount that they are learning. . . . For the first time, these children are valued for what they do. The teachers and the . . . community have exalted them and said that what you do and what you are is important. . . .These experiences are powerful and

significant boosts to their self-image and self esteem." (Masters course work paper, November 2002, p. 9)

### *Diversity of Working Styles*

Only when Seán began to work with the children and teachers in his own school did he realise that the teachers' summer workshops were structured to allow for the development of self-interests and different ways of working (Conversation, July 2001, Mexico). We were trying to facilitate self-structuring rather than enforcing a predetermined structure that people had to work to.— "different strokes for different folks" (Papert, 1996, p.86), because "only if a workshop respects and supports a diversity of working styles, will participants feel comfortable enough to work on personally meaningful projects" (Resnick 1991, p.5). So aware of and sensitive to the idea of different learning styles, Seán watched his students carefully as they explored and developed their projects with the expressive computational materials. He illustrates the diversity of working styles that emerged with some examples in a paper he wrote (Nov 2002) as part of his course work for his Masters degree in education:

> Papert calls people like Derek "Planners with a capital P to indicate that these are people who attach very special importance to Plans" (1996, p.87). As part of our preparation for a project on the regeneration of the local area, I brought a group of students out to look at some of the construction machinery in the local environment. . . . Derek wanted to make a crane, . . .he drew a design plan [and] . . . worked through [it] bit by bit, in a systematic manner. [See Figures 23 and 24, below] He did not deviate from his original design. Also, he was totally immersed in his own design and he was not aware of the work of the other groups around him.
>
> Aaron, on the other hand, is a classic bricoleur, "arranging and re-arranging, by negotiating and re-negotiating, with a set of well-known materials" (Turkle & Papert, 1992, p.6). Aaron started his crane by picking a selection of pieces and putting them together, with a general idea of where he was going. He was continually changing and modifying the model. In contrast to Derek, Aaron was more aware of the other groups working and, significantly, it was he who suggested to one group to use an eight-tooth gear meshing with a crown gear, as a way of slowing down the swivel on their crane. In discussing the differences between bricoleurs and planners, Turkle and Papert observe, "For planners, a program is an instrument for premeditated control; bricoleurs have goals but set out to realise them in a spirit of collaborative venture with the machine" (1991, p.6).

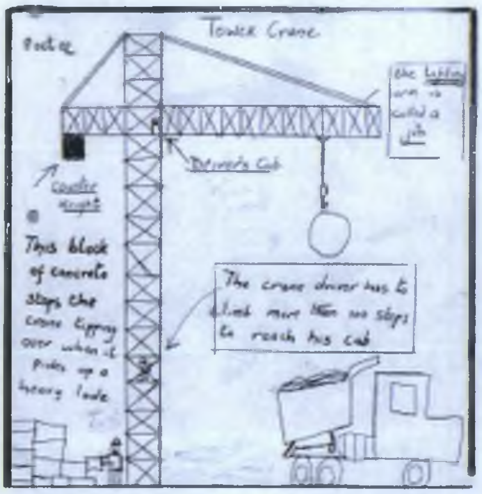



*Figure 23:* Derek's plan for his crane construction

*Figure 24:* Derek testing his crane construction

Seán consciously tries to accommodate these different working styles so each student works comfortably in his own preferred style. He realises that "when children compromise their individual style, they forfeit the opportunity to develop a strong sense of who they are as unique individuals. They are told that who they are and how they think about things is not valuable" (Segall, 1991, p.265). Seán's strong belief in the 'individual' and his commitment to finding the 'uniqueness' of what each boy brings to the world is perhaps what lead him in the first instance to work with these boys in the special class who had been isolated. Now working with expressive computational materials in a Constructionist learning environment he saw a chance to reintegrate these alienated boys, and restore their faith in themselves.

### ***Teacher as Facilitator, Collaborator, Co-Learner***

Seán is careful to allow the boys enough time and space to decide on their own ideas as he is mindful of the fact that many other activities using concrete materials have been impugned as "'hands on' but may be 'heads out'" (Resnick, 1991, p.1). Seán follows the boys' lead in whatever project they want to pursue and supports them so that they are central and active in their own learning. He believes in the principle that "the child's natural curiosity is at the heart of the learning process and provides the purest and most valuable and motivating factor in the child's learning" (Revised Primary Curriculum 1999, p.14).

Here's what happened when Seán was alert to the possibility of a learning opportunity for a boy whose natural curiosity led him in his own direction:

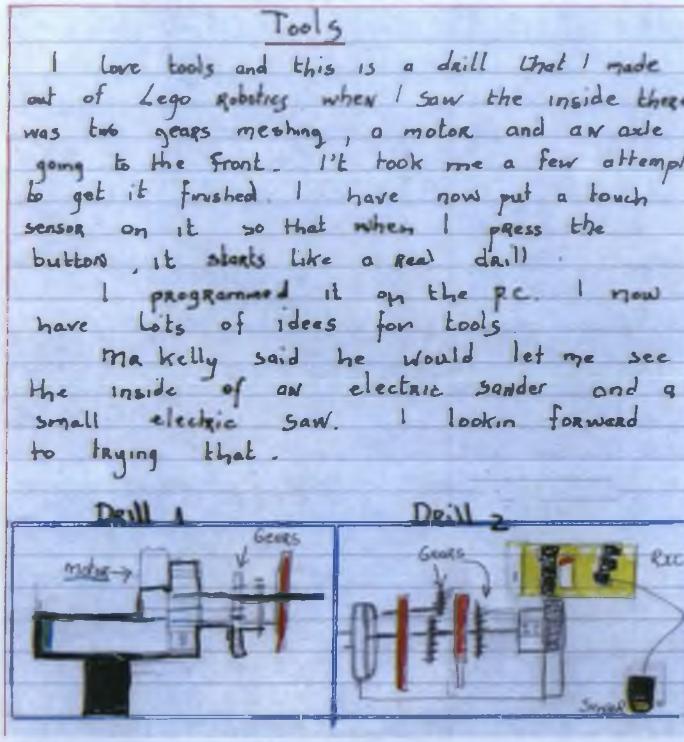
> Whilst putting up the shelves and a press, I noticed that Gerard, one of the sixth class boys, had a great interest in my electric drill. When he came to my room to work with the LEGO Mindstorms, he preferred instead to look at the various tools in my toolbox. During one session, he asked me, "How does a drill work?" I gave him a screwdriver and assisted him in opening the drill. [See Figure 25, below] After a discussion on the parts, Gerard said that he would like to make his own drill, using LEGO materials. There was great excitement and a sense of achievement when he finished the model. [See Figure 26, below] He is now working on putting in a touch sensor to simulate the trigger mechanism on an ordinary drill [See Figure 27, below]. Gerard was doing something that came from an inner motivation and it made the exploration personally meaningful for him. He had now made his own personal connection with the technology (Seán's Masters coursework assignment, Dec. 2002).

Cueing into Gerard's natural curiosity, Seán began to wonder whether any of the other boys were shrinking away from experimenting and working with the new materials as they previously had experienced repeated failure in school. He began to look for alternate ways of encouraging these boys to begin to dabble with the computational materials. During my classroom visits I observed that Seán was very skilled at capitalising on a child's particular strong point and using that as the starting point for a hesitant or insecure child to begin working with the computational materials. He worked alongside them, sensitively encouraging them, to help them develop the confidence to reach out and risk engaging with the computational materials that they were a little unsure of.

*Figure 25:* Gerard Takes the Drill Apart

*Figure 26:* Gerard's Model of the Drill

*Figure 27: Gerard's report about the construction of his drill*


Tools

I love tools and this is a drill that I made out of Lego Robotics when I saw the inside there was two gears meshing, a motor and an axle going to the front. I't took me a few attempts to get it finished. I have now put a touch sensor on it so that when I press the button, it starts like a real drill.

I programmed it on the PC. I now have lots of ideas for tools.

Mr Kelly said he would let me see the inside of an electric sander and a small electric saw. I lookin forward to trying that.



Suspecting that Stephen might be feeling this way, Seán enacted Papert's claim that "the way to become a good learner is by participating with a good learner in active learning" when he arranged for Stephen to "encounter the teacher-as-learner and share the active learning" (Papert, 1999, p.ix) for, at one point, Seán openly admitted that he did not know what to do:

> Stephen had recently won a prize for his penmanship and he received a lot of recognition in the school. He was a reluctant LEGO builder and did not socialise well with the other groups. I felt that this penmanship skill would, if incorporated into a robotic model, be a good entry path into robotics for him. I mentioned to Stephen that we needed a scrolling text model for our Viking Dublin Project. Stephen got very excited. He wrote the text on a piece of cloth. Making this model became a collaborative venture between Stephen and myself. A model was made using pulley wheels, beams, axles and LEGO bricks. The material was stitched around the axles [See Figures 28 and 29 below].
>
> When the motor was attached, the scroll would not turn. I did not know what to do. Stephen suggested putting four forty tooth gear wheels on the axles behind the material because he believed that the teeth would grip into the material. Stephen manually turned the axle and the scroll rotated. He was thrilled that his own idea had worked. . . .
>
> [But] when the motor was attached to the scroll, it would not turn. Stephen did not know that the power being transmitted from the motor was insufficient to turn the scroll. He was getting frustrated, and I felt at this moment that I had to scaffold Stephen's learning. I asked Stephen to pinch

the motor with his fingertips to stop the motor from turning. Then, we looked at applying gear reduction. Stephen now realised that this weak but fast motor energy could be transformed into a slow but strong rotation. I asked Stephen to try and stop the motor from turning. He was unable to stop it and I explained to Stephen that this strong rotation is called "torque." We also looked at worm gears and, as the picture shows, Stephen decided to use this type of gear for the model. We were both very proud of this scrolling text model, and this collaborative experience proved to be Stephen's entry point into LEGO Mindstorms. . . . Stephen displayed his model around the school. Teachers were amazed at how articulate and enthusiastic he was in explaining how the model worked. By the end of the school year, Stephen was one of the most accomplished LEGO builders in the learning community (Seán's Masters coursework assignment, Dec. 2002).

These "teacher-student collaborations (regrettably rare in most school classrooms) . . . [were] rich learning experiences for both sides" (Resnick, 1991, p.5) for, as Seán states, "Making this model became a collaborative venture between Stephen and myself. . . . We were both very proud of this scrolling text model" (Interview, July 2002).

Seán was very comfortable in this role as co-learner as he worked with the boys in his classroom. It was a very honest relationship with everyone earnestly engaged as they tried to solve their problem, and sharing the pride when they had achieved what they had set out to do

*Figure 28:* Stephen's Handwritten Scroll

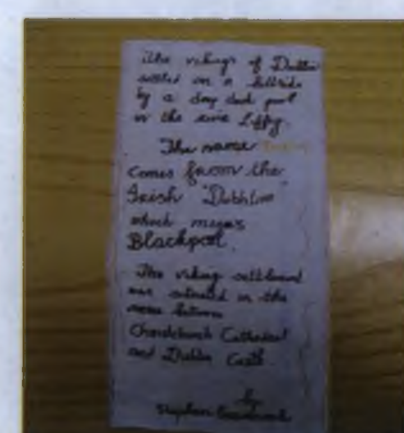


*Figure 29:* The Rotating Scroll Model

### ***Alternative Access Points to Learning***

Seán was especially excited about the computational materials because they can be used in an endless number of ways, to suit whatever project the learner was interested in pursuing. Because there is no predetermined or set way that these materials must be used, the learners' interests themselves easily can be their leverage into new ways of learning—an example, on a micro scale, of the "lifeworld" generating the "systemsworld" (Habermas, 1987) rather than the "systemsworld" (the materials) dictating what is possible. Seán saw his role as developing a rich environment around these computational materials that could promote "alternative entry paths . . . to capture the imaginations of other teachers and students" (Resnick, 1991, p.156).

Stephen's interest in a drill, and Gerard's penmanship, were these boys' entry paths into learning facilitated by the use of expressive computational materials. In the same vein, Brendan's passion for trains excited him and started him working with the computational materials. His group's project was focusing on the regeneration of their locality but he was not particularly interested until one of the teachers suggested incorporating a model of the LUAS (Dublin's new rapid rail system, www.luas.ie ) train. Brendan's passion for trains was the spark that ignited his work with the computational materials: he immediately took up the challenge of building the LUAS.

In the postgraduate class (Oct. 2002), Seán reported that he had been met that morning in the school yard at 8.30 by a very excited Brendan. School did not start until 9.15 a.m., but Brendan had come shortly after 8:00, knowing Seán usually arrived early. Nearly knocking Seán over in his excitement as he ran up to greet him in the schoolyard, Brendan announced, "I thought you'd *never* come! I've been here *ages!* Can I get into the classroom now? Because I had a great new design idea last night for my train! I couldn't wait to get here 'cos I want to try it out!"

Brendan not only had a clear vision of what he wanted to do, but he also owned and controlled his learning because the project he was working on was personally meaningful to him. For Seán, "Here was a child who, in the past, knew more about failure than success—and was now excited about learning. His project had tapped into his sense of wonder and curiosity and had brought a sense of self-empowerment to his life" (Masters coursework assignment, Dec. 2002).

As a result of these experiences, Seán is very aware that the most powerful motivator of engagement with learning is the learner's own needs and interests. So he is now very sensitive to tuning in to each learner's needs and he structures the learning environment to facilitate the learners as they pursue their own personally set learning goals.

### *Peer Collaboration*

By collaborating with each other, the boys have extended the boundaries of their potential development; Seán and the boys all have realised that they have a wealth of diverse expertise in the group. The story of Aaron's advice is an example of the powerful peer-to peer scaffolding that can occur naturally within this type of learning environment:

> One group had just finished their crane structure and they were concentrating on making the crane swivel around. One boy suggested putting a motor on its side inside the crane structure. The top swivelled, but it was too fast. The group then looked at the programme on the computer and reduced the motor power. This slowed the speed down very slightly but the group were still not satisfied. Aaron, who was working on a different model, suggested that they would have to apply gear reduction. He suggested using an eight-tooth gear meshing with a crown gear. Using the gear in this manner proved to be an effective way of building in a gear reduction, while changing the rotation axis [See Figure 30]. This suggestion worked and there was a great sense of shared achievement. As Papert (1990, p.11) points out, the children have "appropriated" the knowledge of gear reduction. In other words, they have made it their own. In addition, they experienced the scientific processes of hypothesising, experimentation and revision (Seán's Masters coursework assignment, Dec. 2002).

*Figure 30:* Gearing Solution Changes the Direction of the Rotation

### *Formal Systems*

Seán found more than one way for the computational materials to "make the abstract concrete . . . [and] bring formality down-to-earth" (Papert & Turkle, 1990). Listening carefully to the children's conversations as they constructed their models, he intuited that they were appropriating concepts and understandings that they would not have an opportunity to develop in a traditional learning environment, where "the conventional route into formal systems, through the manipulation of abstract symbols, closes doors that the computer can open" (Papert and Turkle, 1990).

He noticed children who formerly were unsuccessful in traditional maths activities now demonstrating in-depth understandings of mathematical and scientific concepts as they worked with the computational materials. He recorded this conversation during a building session when David and Dean were attempting to slow down the swivel motion on a crane. (It is worth noting that Dean attends learning support for maths.)

> **David:** We have to put a small wheel with a big wheel [holding up a big gear wheel]. How many spikes on this one?
>
> **Dean:** They are called teeth, it's a forty-tooth gear wheel.
>
> **David**: How do you know?
>
> **Dean:** Look, 4 by 10. One-quarter way round is 10. Halfway round is 20. Three quarters is 30. One full turn is 40.
>
> **David:** Cool!
>
> **Dean:** [Holding small tooth wheel]. This is an eight-tooth gear wheel. Look, 4 by 2. This will have to turn around five times to make the big wheel turn once.
>
> **David:** So, if you put the big one first it would turn the eight tooth gear around five times.

David and Dean have just reasoned out the concept of gear reduction, using maths on their own to understand the physical world of gears.

> The LEGO projects involve a variety of mathematical concepts such as fractions and ratio. Resnick and Ocko (1991, p.8) point out that "in many cases students have previously 'learned' these concepts in the classroom. But students seem to gain a deeper understanding when the concepts are embedded in meaningful design activities." Seán saw his boys make deep connections with the mathematical and scientific concepts. This idea is at the core of the theory of constructionism (Masters coursework assignment, Dec. 2002).

Seán has continued systematically to observe and gather evidence of learning potential when children are immersed in an environment rich in computationally expressive materials. Powerful evidence like David and Dean's story effectively quells criticisms of the teachers and others who may accuse him of "allowing his boys to play around with LEGO and computers all day." When they complain that he is "not covering the curriculum," he can now demonstrate that the very children who had "failed" with traditional methods now actually have appropriated "powerful ideas" that not only encompass the prescribed curriculum but also are far more challenging and complex.

### *Seán's Learning Environment Expands*

By the end of the first year (2000-2001) of engagement with the project, Seán was convinced that working with these computational materials had changed the way he saw his role as a teacher forever. He was happier than he had ever been teaching and had a renewed interest and confidence in his own ability as a learner (School visit conversation May 2001). He wrote in his end of year report that "this year has been a thoroughly enjoyable, rewarding and enriching one, principally because of my involvement with the Empowering Minds Project" (Seán's Report, Summer 2001). When the Future of Learning Group (http://learning.media.mit.edu) at MIT's Media Lab organised its first Summer Institute in Mexico as part of the Learning Hub initiative (http://learning.media.mit.edu/mid_projects.php#active), and the prospect of going was proposed, Seán was first to jump at the chance. Sixteen days of his summer vacation and in excess of a thousand euro of his personal finances were, he believed, a small price to pay for an investment in his learning for the future. He said if he only experienced a fraction of the learning thrills he had experienced over the last year, working with the boys in his classroom, it would be a wise investment (conversation, May 2001).

To say that Seán thrived at the Summer Institute would be a huge understatement. For weeks before departure, Seán prepared, as he wanted to know as much as possible before going so he "could take full advantage of his time there." He would be taking his first transatlantic flight, so that in itself was going to be "an experience to relish." In his typical methodical pattern, he gathered resources (e.g., guide books, articles, video travel programme about Mexico) and shared them among the group who were going to make the trip. Aware of the language difference, he found a simple children's book and a Spanish language tape, and he set about learning the phrases and vocabulary he thought might be necessary for the trip. This was time he had consciously decided he was setting aside for his own personal development and he was actively ensuring that he was going to make his time in Mexico as worthwhile an experience as possible.

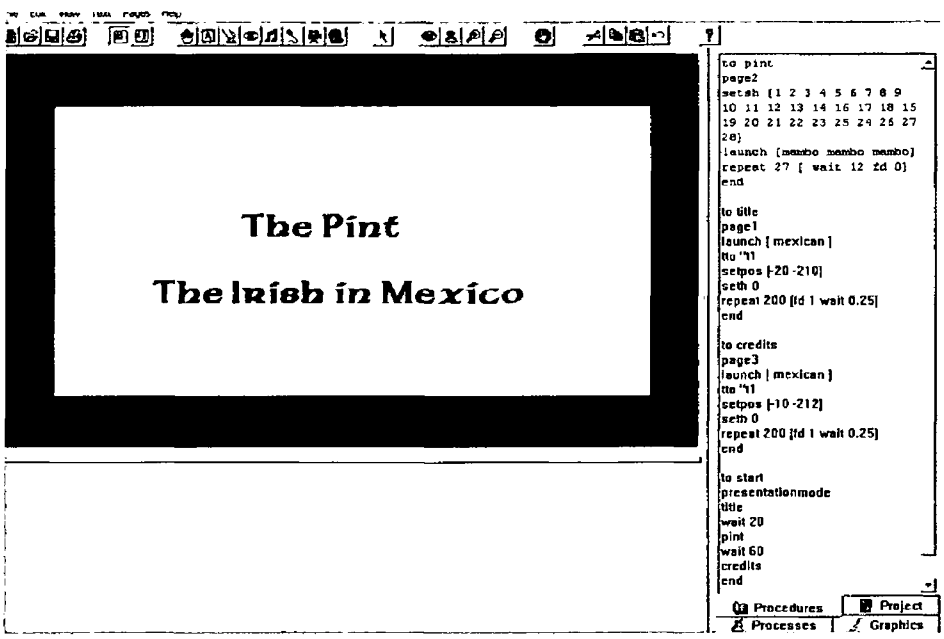
### *The Pint*

One of the workshops during the first week of the summer institute led by Roger and Paulo (students in the Future of Learning Group at MIT ML) demonstrated how, using a digital camera and Microworlds software, it was possible to create an animated story. While on a trip to the Pyramid of the Sun and the Moon, Seán, Donal, Tom and I had the idea of using this idea to create our own story of our day out. It was incredibly hot and we had stopped at a local restaurant for lunch. We tossed around a few ideas while waiting for our orders and decided on a loose story line with the restaurant providing the setting. Seán was the main character who, having travelled all day, was gasping for a drink. This was to be a send-up of the stereotypical Irishman's love of alcohol.

We developed the story with comic overtones, involving the rest of the group and even the waiters, who had fun playing along with us although they thought we had lost our marbles. Two of us (Donal and I) took the photos. Besides his starring role, Seán (who holds an Equity card and often works as a film extra) directed, embellishing the story line with impromptu ideas as well as insisting we reshoot some scenes from different angles to allow us to change the storyline later if we wanted to. Drawing on his experience of film locations and the kinds of scenes that would give the narrative momentum, he thoroughly enjoyed his role as director. Fired by enthusiasm while the bus was stuck in traffic on the way home to the hotel, we began viewing all the digital pictures to put them into a preliminary sequence, which we thought, might work for our story. Seán always with a notebook to hand kept a note of the numbers of the photographs we initially decided upon. Typically through, he insisted we rechecked each shot several times discarding them if they had poor lighting, lacked definition or didn't fit in with the storyline. We were so excited at the idea of putting the story together we continued working on the story boarding sequence at the hotel for a number of hours that evening.

Next day, Seán, who had been thinking overnight, suggested a reordering of the sequence to help the flow of the story. Taking account of the changed sequence, we imported the pictures into Microworlds and wrote a procedure to sequence the pictures correctly. Encouraged by what we had achieved, we got more ambitious, deciding to include a rolling title card: The Irish in Mexico. We embellished the title with Irish Celtic art and arranged to have Mexican music playing as the title rolled up the screen (See Figure 31 below).

*Figure 31:* Screenshot: Title Card (with some programming procedures*)*




When we showed our animation project to the other teachers it caused great hilarity and became a focal point of interest at the Summer Institute with many asking how certain things had been accomplished which the group took pride in explaining.

### *Learning Redefined*

Seán never would have believed that he was capable of being part of a group who could make this animated sequence of which he was so proud. For him, *The Pint* symbolised his big break-through in understanding his own passions and interest in acting and film, and the ways they were instrumental in unleashing an array of new possibilities for learning, using digital technology. He had felt a little overshadowed by Tom and Donal's technological expertise, but the digital animation experience showed him that the combination of their skills and his other talents and experiences had catalysed a rich learning experience for all three of them. During this process he had experienced collaborative learning as each member of the team contributed in their own unique way; been part of a group which set their own learning goals; experienced ownership and control of his own learning; understood how powerful learning can be in a meaningful context; and had tremendous fun learning many new skills while working with a range of digital tools and materials

Seán told me on the journey back to Ireland that the Summer Institute was the turning point for him and made possible some of the best learning experiences he had ever had.

### *Reflecting on the Mexican experience*

Reflecting on the experiences later when he returned to Ireland he told me (conversation November 2001) that the Summer Institute in Mexico would always be a special time in his life. He had met wonderful people (e.g., Edith Ackermann, David Cavallo, Cynthia Soloman, Carol Sperry, Michael Tempel, Gary Stager and Rahual Bhargarva) whose words and actions made a lasting impression on him, causing him to think about issues he had never thought deeply about before. He commented to me (January 2003) that when he was preparing his literature review for his Masters dissertation he felt a deep personal connection to their writings and their ideas.

#### *Shared concerns*

During his time in Mexico Seán was struck by the fact that the other teachers from Central and South America were concerned with the same issues as the Irish teachers had been when first confronted with the computational materials and the constructionist style of working and learning. He recognised similar apprehension and tension when these teachers were faced with the challenge of setting their own learning goals. Seeing these teachers have the same reaction to the materials as he did at his first workshop the previous summer gave him renewed confidence that this was a common reaction to new experiences and something not to be ashamed of. He talked with many of these teachers sharing his experiences with them, which they found comforting and encouraging. He realised that because he had already gone through this stage and had worked with the computational materials in his classroom he was more prepared and open to the new ideas that were being presented at the Institute (Conversation with Seán, September 2001).

#### *Open to new ideas*

Comparing the two experiences (Irish summer workshop 2000 and Mexican Institute 2001) Seán preferred his experience at the Irish workshop as an introduction to constructionist learning and using computational materials. He felt the smaller group was an advantage, which was strengthened by everyone initially using a common set of computational materials for an extended period of time. This helped develop a group identity as people struggled with similar problems using these materials. A common language developed to describe the learning processes experienced making it easier to share and communicate individual experiences that contributed towards an understanding of constructionist learning. Using this common set of computational materials and developing projects also meant there was a depth in the learning experienced rather than a surface skimming which would have been the temptation if their had been a range of computational materials to choose from. The traditional belief that you "had to cover everything" would have prevailed emphasising quantity rather than quality. So Seán believes that although he was ready for the Mexican experience and excited by the prospect of exploring learning using a variety of computational materials if it had been his first experience he thinks he may have been overwhelmed by the variety of materials available and the large number of people present (Summary of a number of conversations with Seán during October to December 2001 as he was working on his dissertation).

### *Situated Learning*

It was as a result of his experiences at the Summer Institute Seán realises the importance of looking beyond what someone builds (i.e., "the product" – the model / artefact) to understand the learning process and what informed the construction, the process of refinement and series of iterative developments that have resulted in the finished product. He now understood the importance of context (social, emotional, historical and physical) in learning. As he explains, it is the "whole experience" that we remember and it is difficult to entangle the pieces. It helps to have an external object, which holds things together for you and is in essence what Papert refers to as your "object to think with". Often to the outsider just seeing this object will not demonstrate the wealth of learning incurred in its construction (Conversation, November 2002). To illustrate what he means Seán always refers back to his experiences building the Mexican High Priest model at the Summer Institute (July 2001, See Appendix G). If someone just saw this model perform its dance they could not appreciate the rich learning experiences and intricate group dynamics involved in its construction. Most people would perhaps be mildly interested in its construction and its ability to perform a rather slow and dignified ceremonial 'dance' routine. However, for the group who built it, this model was the culmination of long hours of collaborative research and dialogue, and symbolises the fusion of their experiences of the ancient Mexican culture with the digital technologies of the twenty-first century. It was this experience particularly that lead Seán to understand the deep personal connections people can have when working in this constructionist way using expressive computational materials. So he is now more aware of looking beyond the artefacts his students create and is conscious of the entire process that has culminated in this external object.

*Developments resulting from the Summer Institute*

Coming home from Mexico Seán felt he had learned so much and had a much broader understanding of what being digital meant in learning. He was eager to try out some of the ideas as soon as he got back to school e.g., Digital video editing; Claymations (http://www.stager.org). He was also more confident in his own abilities and was really looking forward to doing the Masters postgraduate course to find out more about constructionist learning and to pursue some of the questions that were puzzling him e.g., "Was it these computational materials that encouraged constructionist learning or was this type of learning possible without these expressive materials"?

### Seán and His Partners, Back at School

*Understanding his own learning style.*

What also helped Seán benefit more than some others from working within EM the group was his understanding of how he himself learns

> I've always considered myself as a team player. I wouldn't have had many opportunities in the school but this [project] has reaffirmed this and I really do feel part of a group now. I value that big time. I consider myself as a team player not an individual (Interview July 2002).

Seán realises that he learns best when he works with others, as they provide him with other viewpoints and perspectives, which in turn cause him to reflect on his own understandings:

> We have a great camaraderie. Collaborate as partners. Bounce ideas off one another. Always open to fresh approaches. So I'd regard them as really crucial, a very, very important part. I'd find it very difficult to carry it on my own so it's a combination of the parts. . . . We collaborate with one another and that's very important, especially when you want to try out some new ideas as well (Interview July 2002).

*Everyone's not like you.*

It is difficult if not impossible to mandate collaboration among teachers in a single school for a myriad of reasons, not least the jealously guarded "legendary autonomy" of teachers in the Irish education system (OECD 1991). When teachers hold such strong beliefs about professional autonomy and identity, seeking the co-operation and collaboration of colleagues is often perceived as a weakness rather than strength and a willingness to learn (Sugrue, 1996, 1997). But the reflective thinking and collaborative inquiry within the EM community developed the skills and confidence necessary to sustain teacher change (Darling-Hammond 1996; Hamilton & Richardson 1995).

Within a few months of his involvement with the project (Aug 2000-June 2001), Seán noticed a tendency among the teachers to assume that they all thought alike, and that these assumptions were dislodged only by the force of revelation from another teacher. In a conversation at a cluster meeting during his first EM term, Seán was startled into realising that others had very different ideas about how to work with the materials. His partner, Lorraine, was describing how shocked she was at how little sophistication the children had when building with the materials: she had drawn an illustration on the blackboard indicating they should overlap the bricks on each row to build "strong walls." She also reported that her students had squabbled so fiercely over the "LEGO people" that she now kept them in a box on her desk, and the boys were not allowed to have them.

Seán instantly realised that he would never have known what her approach in the classroom was unless there had been the structure of the cluster meeting and the ethos of trust and acceptance (Zetlin et al., 1998; McLaughlin & Talbert, 1993). He resolved that they would make a concerted effort to try to have similar discussions with each other when they returned to school.

*Fostering dialogue.*

Seán told me that he realised dialogue amongst the teachers in the school could not take place in vacuum, nor was it likely to occur spontaneously much of the time (school visit, February 2001). He realised that "workshops alone seldom alter dispositions and views of self" and that "efforts that hope to build capacity must use a wide range of strategies" (Floden, Goerttz and O'Day, 1995, p.20). He wanted to extend the ambience of the EM workshops back to his school site, with his partners. A feeling of trust and acceptance had developed across the EM group, which allowed people to feel safe (Maslow, 1972) and be in a position to take a risk to express their opinion and not to feel as if they were going to be judged (Sugrue et al., 2001, p.39; Grossman and Wineburg, 2001). Only in this "safe environment"—not at school, where he nominally worked *with* her—had he learned how Lorraine felt about the materials and how she was using them. Back in school, they talked only by chance and infrequently. He realised that he and his partners needed a structure or shared context within which they could have these conversations regularly.

Donal and Seán had been working closely with one another as the physical arrangement of their classrooms facilitated this—the computer lab where Donal worked most of his time was located next door to Seán's classroom. They resolved to work more closely with Lorraine for the remainder of the school year (March – June 2001) and began discussions with her to work out a way of arranging this and putting a structure in place.

Soon, the three decided to work together on a common project. But they did not want to work in their separate classrooms, as is usually the case in traditional project work, with participants responsible for separate parts in different areas that then come together to form the overall project. After consultation with the school principal, Seán set in motion organisational changes (timetabling and suitable working space) in cooperation with two other teachers (mainstream and computer resource) to facilitate two groups of children (special class and third class mainstream), varying in age (nine to thirteen years) to work together on a project over a sustained period of time. The teachers reorganised their schedules and work environment so that all three of them could work together in the larger workspace, along with all the boys from their mainstream and special classes.

### *Breaking Traditional School-Wide Boundaries*

When the groups merged, traditional boundaries collapsed: The computer resource teacher was working in a classroom rather than the computer lab, a special class teacher was working within a mainstream class, and a mainstream teacher was no longer working alone but collaborating with two other teachers. When these arbitrary distinctions evaporated, many of the stereotypes and assumptions wafted away, too, and ideas began to flow in all directions among the mixed group of students and the three teachers. Straight away, the students saw:

- ➢ The computer resource teacher could work in environments other than the computer lab, which helped to promote the message that technology was not something set apart from regular classroom work or that it required only specialist teachers to work with technology.
- ➢ Multiple classes and teachers could work collaboratively on a project that succeeded in crossing age, grade and subject boundaries.
- ➢ Teachers could work as a team with a number of different grade levels on a common project rather than conforming to the traditional model of one teacher per designated group of children.

- Children from different grade levels did not have to be kept apart but could work effectively together on projects of mutual interest.
- It was possible to work on projects which crossed multiple subject areas rather than being bounded by discrete subject areas only.

With teachers and students in this new configuration at Seán's school, "tradition and 'the way we do it here' was challenged and discussed as a means to new insights and practices" (Hord, 1997, p.37). For the teachers, the new structure was at least as big a change as for their students. The school system of segregated classes and prescribed curriculum has an inbuilt "no questioning" function that inhibits teachers from reflecting on their practices. Never having to explain how they practice their profession, they haven't had the benefit of exchange with others and may continue in obsolete practices or methods out of habit and isolation.

In this new situation, though, with three teachers and two classes in one room, all three teachers had to externalise the rationale behind their decisions and actions. Coming together as they did, to work collaboratively with their children on a project motivated by mutual interest, the teachers took a fresh, questioning and critical approach to learning. Each teacher watched the others interact with children, and different children react to one another, and to the other teachers. Naturally, questions arose, and spontaneous, reflective discussions became part of the daily fabric of classroom life as these teachers worked together and grew to know each other personally and professionally. Cranton (1996) had argued that educators need to be aware of and question critically their "meaning perspectives" (i.e., the "...framework...that shapes our perceptions of ourselves, others and our surroundings) on a continual basis. Such questioning is necessary because if the "meaning perspective" (Cranton, 1996) upon which a teacher bases the construction of a learning environment is restrictive then the environment will not be capable of fostering learning for all learners. These teachers had begun this self-directed process of questioning their individual 'meaning perspectives', which are "formed through experiences" (p.96). By collaboratively working in an open and supportive learning environment which challenged them to question their understandings they were ensuring that they were engaging in a continual revision of perspectives on practice, which Cranton believes to be "the essence of professional development for educators" (Cranton 1996, p.116).

*Dummies no more!*

Seán's idea of a joint project succeeded in breaking down traditional barriers of prejudice. Working with the special class changed the mainstream boys' opinion of the children they had previously scorned. Seán's boys, previously shunned and ridiculed as "dummies," were now "consultants"—even "geniuses"!—as they demonstrated that they could make and do things that some of the mainstream boys were not capable of doing:

> Brendan from the special class has a brother, Peter, in the mainstream class, who is working with LEGO Mindstorms for the first time this year. While Brendan was showing his LEGO car [See Figure 32 below]—which included a rack and pinion steering mechanism—to the third class, a classmate of Peter told him that he was "lucky to have a brother who is a genius at LEGO" (Master coursework assignment, November 2002).

*Figure 32:* Brendan's Car

Now, instead of being ashamed of having a brother in the special class, Peter is proud of Brendan, as he realises that his brother is, indeed, a "genius at LEGO." But such changes in attitude were possible only because Seán, Donal, and Lorraine broke the traditional segregation barriers within the school. The children in the mainstream class "would not have known of Brendan's ability unless they were working in the same learning environment and engaged with the same materials because he would have been tagged as just another 'failure' from the Special class" (Master coursework assignment, Nov. 2002).

## *Extending the Community Within the School*

At the Empowering Minds summer workshops, we encouraged the use of other craft materials to extend the LEGO building materials. Seán built on this idea as a way of personalising projects and contexualising the models his students children built. When they were working on the Viking theme, for instance, they used lollipop sticks, paints, fabric and papier-mâché in the construction of models such as a monastery, a round tower and a Viking ship (See Figure 33 and Figure 34 below). The boys themselves recruited another teacher to their projects:

> Bernie . . . has a talent for art and craft, and two of the boys enlisted her help while they were constructing the monastery. She said that she could help them with the craftwork, but she felt she would be of no assistance with the LEGO construction. In her own words, "I am not very mechanical." However, in the course of working with the boys, Bernie got very involved and the experience of combining art and craft with the LEGO materials, turned out to be her path into LEGO Mindstorms" (Seán's Masters coursework assignment, Dec. 2002).

*Figure 33:* The Round Tower

*Figure 34:* The Viking Longboat

Bernie continued to work with the boys on their various projects and became very interested in the computational materials. She was amazed at how focused and tenacious the boys were, sometimes even wanting to stay and work rather than go outside during break time. She talked at length with Seán about how his students seemed to be blossoming and gaining in confidence daily. Intrigued, she began to spend more and more time working alongside the boys as they developed their projects.

### Seán's Third Year: Extending the Learning Community Even Further

When Lorraine took a career break from school in June 2002, at the beginning of Seán's third year with the EM community, Seán and Donal extended their collaboration to include Bernie, a support teacher and Conor, a mainstream fourth class teacher. About 20 mainstream sixth class boys who had previously worked with Lorraine were also included in the extended group. While Seán and his special class worked with Conor and his mainstream fourth class, Seán also worked with Donal and Bernie and the sixth class boys in an after-school homework club. Whenever possible, Seán also worked the sixth class boys in with all the others.

He knew that moving from a discrete, subject-based curriculum to Constructionism challenges a teacher's every belief and assumption about teaching. So in order to adapt to the resulting changes in their roles, teachers "need time to experiment, reflect and discuss with others in a supportive learning environment" (Butler et al., 2000, p.2). Seán developed an EM-style environment within his own school, extending to the new teachers the elements of Empowering Minds that he had found helpful in his own learning: a supportive learning environment; time to discuss, share and reflect upon ideas within a group setting; and opportunities for learning together with the children.

Seán set up structures to facilitate this dialogue. He and Donal met regularly with Conor and Bernie, to discussing ideas, reflections and problems, and to provide feedback and advice. To prepare for these discussions and as an aid to their own personal reflection, all four of the teachers kept journals where they recorded the ways they and the children engaged with the computational materials and interacted with one another, and they included reflections and comments on their own evolving roles. Informed by his own experience, Seán strongly believes that "having this supportive environment means that teachers can take risks in safety as they know that if something goes wrong, a helping hand is always available to provide advice and support" (Butler et al., 2000, p.5).

During these group discussions, this small group immediately confronted the same issues that the other groups of teachers faced when they begin to work in a constructionist way using expressive computational materials. . At their very first meeting for example, they discussed the amount of time that was required working in this constructionist way and the guilt feelings they were experiencing now that other areas of the mandated curriculum were not being 'covered'.

> In our first discussion, Conor expressed his concern about the length of time that was being devoted to LEGO Mindstorms. He was concerned that other areas were being neglected. This provoked an interesting discussion about what is important in education. Is it better to engage in higher quality investigations or be exposed to a higher quantity of ideas? We all agreed with what Brooks and Brooks (1993, p.39) observe: "Most curriculum simply pack too much information into too little time, at a significant cost to the learner." Our group accepted that it is only through purposeful, meaningful and in-depth investigation of ideas, that skills can be acquired and concepts can be learned (Master course work assignment, Nov. 2002).

This inner conflict is a very common issue. I've seen many groups of teachers wrestle with their existing beliefs, the mandates of the system and the demands of the existing curriculum—all while trying to create and implement a Constructionist learning environment for their students. Most discussion of the first Empowering Minds teachers' group (Easter 2000/ Summer 2000) centred round these concerns; John Bilotta (Summer 2000) testified that the teachers in Rhode Island had similar fears and worries when they began working with the prototypes of these materials; the teachers in Costa Rica (Jan 2001) and at the Mexican Learning Institute (July 2001) had these same issues high on their agenda of concerns. With experience, the teachers invariably realise that "interesting Programmable Brick projects require extended blocks of time; they cannot be squeezed into standard fifty-minute class sessions" (Resnick et al., 1991, p.6). They always find that their quandary's solution begins with redesigning the daily school schedule. Because Seán already had recalibrated their school time so they weren't scrambling to cover required curriculum, his colleagues had sufficient time both to acknowledge the conflict and then to move swiftly on to interrogate their own assumptions about learning—the first step on the road to self-determined learning.

The decision to spend extended time working on projects using these computationally expressive materials is initially difficult as it runs contrary to deeply ingrained traditional beliefs and practices. Robert Lindberg (1995) reminds us that although belief must underlie a permanent change in human behaviour, belief is most likely to follow behaviour rather than to precede it. Therefore getting individuals to take action or to behave in certain ways can perhaps be a more efficient starting point than trying to change beliefs so that behaviour will follow. However, taking action must be coupled with a supportive environment. With this precept in mind, Seán and Donal supported Conor and Bernie as they worked alongside them in the classroom, and engaged in reflective discussions with them. In this supportive environment, Bernie and Conor were able to risk leaving aside traditional classroom practice and try on the new Constructionist approach for size. And it was a neat fit: they both got lots of positive feedback from parents and children, encouraging them to continue their Constructionist approach. In his journal, Conor recorded some positive parental comments, and noted that "Thursday is becoming known as 'Mindstorms Robotics Day' and it is no surprise to see that Thursday's attendance is way up on any other day" (Conor's Journal, January 2003).

> An examination of Conor's roll book show that there is an average of three boys absent each school day. However on Thursdays, there has been full attendance at thirteen of the twenty Mindstorms sessions and, in the remaining seven sessions, there has been only one absentee on each of the mornings. This demonstrates that the children value the Mindstorms work and they have made the decision to come to school on those days (Seán's Master's Dissertation, 2002, p.71).

Conor also noted that he was amazed at the children's knowledge of gears (Master course work assignment, November, 2002) and that quite often they knew far more about how to build with these computational materials than he did. Because these teachers realised that they no longer "had all the answers," they became graphically aware of the variety of learning styles and have become "learners along their students" (Butler et al., 2000, p.4).

> Both Bernie and Conor said that adopting the role of facilitator was giving them greater insights into the children's' learning styles and that they were learning so much from the children. (Master course work assignment, Nov. 2002)

If Bernie and Conor continue "to implement change both in their classroom and in the school in general" (Butler et al., 2000, p.4), rather than change being imposed from the top down, this evolving Constructionist approach could result in the creation of powerful learning environments for all learners—teachers *and* students—within the school.

## *In Conclusion*

### *Learning, and Being Part of a Group*

When asked for the highlights of the project, Seán ranked the value of "working with the other teachers as well as the sharing of ideas" at the top of his personal greatest hits (Interview, July 2002):

> I've learned a lot in the last two years. If I were to take it in segments of how I've change in the past 22 years' teaching, the last three years have been the most dramatic changes really in me. What I've learned and how happy I am in the job" (Interview July 2002).

He attributes much of this growth to "being part of a group, being part of a community," the members of which he regards "very much as partners" (Interview July 2002). This is consistent with the literature around teacher development that clearly demonstrates ongoing collegial support is essential to meaningful and long- lasting teacher change (Showers & Joyce, 1996; Darling-Hammond, 1996; Caccia, 1996;

Raywid, 1993; Ruiz et al., 1995). And this support is particularly efficacious when coupled with opportunities for reflective thinking (Darling-Hammond 1996; Hamilton & Richardson 1995). Rosenholtz (1989) maintains that teachers who felt supported in their own ongoing learning and classroom practice were more committed and effective than those who felt isolated and without support. Lindeman (1926) suggests that teachers' own personal needs and interests, coupled with their experiences in the classroom, should form the starting point around which to challenge and build new ideas and perspectives on learning. Seán believes that he has made the greatest strides in his own learning in the context of the Empowering Minds learning community because it supports and responds to all the teachers' personal needs and interests.

> I feel very much *in* the group and that's the spirit that we've got in the group. . . . Everyone is being very open with their experience or lack of experience in the area . . . right from the moment, "Go!" So people are very comfortable with one another. And I think that's very, very important (Interview, July 2002).

Talbert (1993) argues that support from such professional communities not only offers "the most effective unit of intervention and powerful opportunity for reform" (p.18) but that "participation in a professional community . . . supports the risk-taking and struggle entailed in transforming practice" (1993, p.15).

### *New Learning Leads to New Growth*

Since his involvement with the EM project Seán is more "open to new ideas" resulting in further professional development opportunities that have "opened so many other doors" for him: "Even my own development—giving a course this year to other teachers in the summer—that's something I haven't done before. Talking to the group has given me a lot of confidence (Interview, July 2002).

He also feels that "there has to be a fun aspect to [learning] as well, which is very, very important." Because the EM learning environment was enjoyable and boosted his self-esteem, Seán stayed motivated (Tough, 1979). For him, teaching now extends "beyond the moment": "I'm thinking about it when I'm not there as well, reflecting back why I'm doing certain things" (Interview July 2002). He is continually aware of and interrogating his "meaning perspective" (Cranton, 1996). Using his classroom experiences as "an object to think with" (Papert, 1986; 1991), he has embedded his learning "in the very routines of practice" (Sugrue et al., 2001, p.8). Seán believes he has "developed a lot" because he has "found something that [he's] very interested in [himself]" but also because his own self-esteem has been boosted.

> [Teachers] spend a lot of talking about the kids self-esteem but . . . to develop the kids' esteem, you have to have good esteem yourself, which is very important. . . . Mine has been given a great boost with the project (Interview, July 2002).

The "positive feedback [he] got . . . from different people [the children, the parents, the principal], the two newspaper articles" [6](Interview July 2002) about his work, and numerous visits from other educators to his classroom all helped give him the confidence to host a discussion about his work with the learning-support teachers' group in his area (January 2002) and to act as a facilitator in workshops using computational materials for undergraduates (final year preservice elective, March 2002); teachers (workshops for primary and post-primary teachers, August 2003), Liberties Learning Initiative Workshops, November 2003 & February 2004); and care workers and parents (Disadvantaged Forum, July 2002). This cycle of positive reinforcement prompted him to take increased risks branching out in ways he never would have considered prior to EM:

> Now I'm doing the Masters course this year. . . . The assignments . . . all have contributed to me in the last couple of years. I've had an interest in video work which has developed into using digital video technology. I wouldn't have had an opportunity to do that if I wasn't in the project. Even my interest in computers. They've all come now as a result of the project (Interview July 2002).

In his four years with the project, Seán has gone through three distinct developmental phases. (See Figure 35, below.) This progression highlights the fact that it takes time for new technology to give rise to new practices and the new culture that support them (Caperton & Papert, 1999). It also supports claims that short, skill-based courses (Drury, 1995, Chapter 2; Fullan, 1992, p. 34) and staff development in the form of "one-shot" workshops have been mostly ineffective in promoting new teaching behaviours and the confidence that is required to initiate change (e.g., Showers & Joyce, 1996). Teacher learning requires "meaningful time" (Raywid, 1993) and commitment if substantial rather than cosmetic changes in practice are to occur (Eraut, 1994; Guskey and Huberman, 1995) and teachers' thinking is to develop to the level of "critical judgement" (Papert, 1990).

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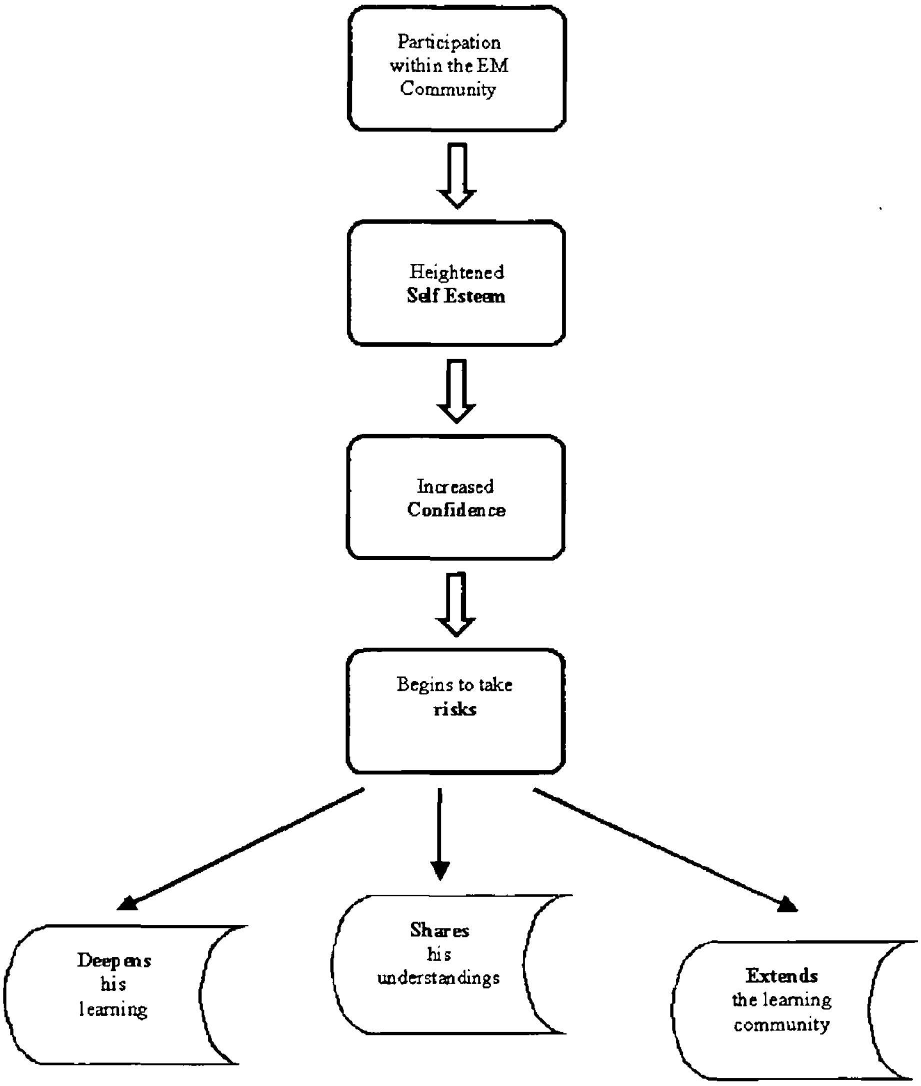
[6] Class@ct, the Magazine for Teachers, Eircom Learning, Spring Issue 2001
Education Supplement, Irish Times, 9th February 2001

Seán's three stages break down like this (See Figure 35):

*Figure 35: Stages in Seán's Development into a Self-Determined Learner*




He spent the first year (August 2000 – June 2001) gradually immersing himself and the boys in the use of the computational materials. He developed a deep appreciation of the complexities of learning and the potential of the boys in his special class, witnessing a changing profile of the special class within the school and the beginning of a breakdown of traditional boundaries and assumptions.

During the second year (July 2001 – August 2002), inspired by the Summer Institute, Seán began to spread his wings. He steadily gained confidence as he developed and enhanced learning possibilities for the boys by using a variety of new digital technologies. He made enormous strides in his own personal learning, particularly in the use of digital video, and now he advises the group regularly in this area. He also began a Masters degree programme, using his new classroom practice as the focus of his personal reading and learning.

Prompted by the departure of one of his school team as the third year (September 2002) began, Seán extended the EM community within the school by capitalising on the continuing interest of the children who previously worked with the computational materials and the interest expressed by two other teachers. With Donal's help and support, Seán began to share and extend the Constructionist culture. He is excited about working with some new teachers but also realises that working in a Constructionist way and developing a learning community within the school presents challenges unheard of in the traditional approach to schooling. He is aware that "the road of the new education is not an easier one to follow than the old road, but a more strenuous and difficult one" (Dewey, cited in Resnick and Ocko, 1991, p. 6). However, Seán believes the new road is worth following as it "has brought a sense of self-empowerment and self-respect to the lives of the children":

> It has revived their interest in learning, by tapping into their natural sense of wonder and curiosity. . . . The [computational] materials are being used for personal and social reflection, articulation and creation. . . . It is the embodiment of meaningful learning that requires them to converse and reflect on what they are doing. In this learning environment, there is creativity, discovery, collaboration and a richness in human relationships. As the teachers engage with the materials, they have become learners alongside the students. Using the technology in this way can help teachers and children become independent, life-long seekers and constructors of knowledge (Masters coursework assignment Nov. 2002).

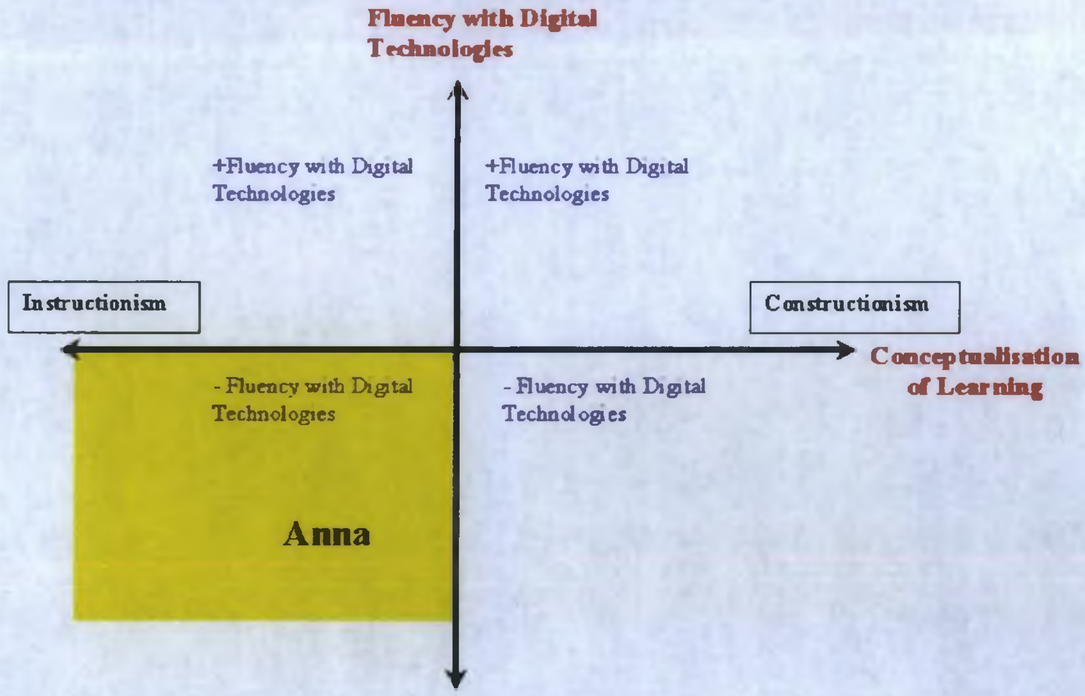
Seán's positive experiences with the computational materials in the Atelier-style learning environment kick-started his transformation into a self-determined learner. His subsequent classroom experiences and the supportive EM community gave him the confidence to begin taking risks. He has begun to develop his own understandings of what being digital can mean in learning, and is also firmly committed to continue developing a culture of learning within his own school that includes the teachers, children and wider community. As he states himself,

> Being part of . . . the Empowering Minds Project, has had the effect of re-affirming the validity of the work being done in our school. . . . For myself, involvement with [the Empowering Minds project] has brought a better understanding of my own learning style and an appreciation of the necessity for encouraging diverse styles of thinking and learning. In addition, it has made me realise the importance of creating learning environments where children [have access] to the tools they need (Masters coursework assignment Nov. 2002).

## Case Study 2: Anna
### *Fight or Flight!*

> Traditional epistemology gives a privileged position to knowledge that is abstract, impersonal and detached from the knower, and treats other forms of knowledge as inferior. But feminist scholars have argued that many women prefer working with more personal, less detached knowledge and do so very successfully. If this is so they should prefer the more concrete forms of knowledge favoured by Constructionism to the prepositional forms of knowledge favoured by Instructionism (Papert, 1991, p.10).

*Figure 36:* Anna: Traditional Teacher/Learner, New to Digital Learning




### *Introducing Anna*

Anna was among the people in the group who most intrigued me. She seemed to stand in complete contrast to Papert's assumption about female learners.

When you first meet Anna, she comes across as strong and forceful; enthusiastic, but on her terms in that she likes to be in control of the situation she finds herself in. She does not like ambiguity and prefers activities to be structured for her. She persists when she believes firmly in her objectives, but as she states herself, she can be optimistic to a fault, tending not to think things through before she launches into a project (Conversation, February 2001). But over time, Anna emerges as insecure and extremely shy, which may account somewhat for her blustery nature and strong need to be in control

Anna strongly insisted that she was not "technical" in any sense of the word and had no hobbies or interests that involved working with materials. Even about the house, the nearest she'd get to DIY is wielding a paintbrush on a rare occasion. However, she says this does not inhibit her from recognising that other people absolutely relish and thrive on this type of activity, and that she could encourage it in her classroom. When her son was little, for example, she bought him all sorts of building materials, but it was her husband or her mother who sat down with her son to play with them, as Anna herself never enjoyed the type of interaction and engagement with manipulative materials (Conversation, July 2001). An avid and wide-ranging reader, Anna also particularly enjoys meeting up with friends and engaging in long discussions.

Anna has taught for 25 years in what used to be a small village school on the outskirts of a large town approximately twenty miles from the capital city. In fact, she attended this school as a child herself, when it had only 4 teachers. However, with the spread of urbanisation, the school has grown to 17 teachers (13 class teachers, two resource teachers, one learning-support teacher and the school principal) and 370 children. Most of the children now originate from urban rather than the former rural backgrounds. The parents are interested and ambitious for their children and are eager to see new digital technologies used in the school.

Anna tries to keep up to date in her teaching and voluntarily attends summer and evening in-service courses on a range of topics. Organised mainly by the local education centres, these courses are all once-off inputs with no follow-up or support structure.

> Most years I would have done something during the year as well, but it would always be something that would spark my interest. . . . I'd only do a course if I was interested in it. . . . It would have a broad appeal rather than anything specific. . . . Loads of everything, really (Interview, May 2002).

The wide spread of courses is probably due to the fact that Anna regarded herself "as a jack of all trades rather than a master of any." However, she admits that she did "focus very much on the three Rs" in all her professional development.

## *Anna's History with Computers*

Her experience using digital technologies was limited. However, she was interested in finding out more as she realised that we are surrounded by technology in the modern world and "for children to do well, they should be knowledgeable about their uses" (Conversation, August 2000). She was also keenly aware of the parents' and her principal's desire for the children to use digital technologies, so she was confident of their support in this area.

## *How Anna and Empowering Minds Came Together*

From my first encounter with Anna, she was very eager to be involved with the project. She attended the project's open day (April 2000) and information evening (May 2000) at St. Patrick's College. She spent a great deal of time talking with the teachers and children about the types of activities they had been engaged in, the topics they explored, and the amount of time they committed to working with the materials. She talked with me at length, and I gave her my email address if she should require further information. Anna rang me and sent me many emails, asking for more details and information about how her school could become part of our project group. She was very proactive in the selection process, eliciting the active support of her school principal. He was supportive as he realised that involvement in a high-profile project with technologically rich materials could satisfy parents' wishes that their children be actively engaging with new technologies (Conversation, June 2000).

## *Choice of Partner*

Once she realised that having another member of staff was a prerequisite for eligibility in the selection process for the project, Anna began to encourage her colleague, Siobhán, to become involved. Anna was careful to select someone whom she felt she could get along with on a personal level and work with professionally. Siobhán was in the same age bracket and shared much of Anna's values regarding school and children's learning:

> I think it is great to have Siobhán within the school. The odd time she drives me absolutely scatty, and I'm sure I drive her scatty. . . . You can grouse and grumble at one another, but we get on very well, and it's great to have her" (Interview, May 2002).

More important, Anna saw Siobhán as a foil to her own personality. Siobhán is cautious and slow to commit herself, and Anna regards her as a good sounding board. Siobhán thinks hard and, in the workshops, asked lots of questions—so many that she often came across as being quite negative. However, she was just "covering all the bases" to know exactly what she was getting involved in.

Anna, on the other hand, knew that she was inclined to be hasty and rush into things headlong, sometimes blinded by enthusiasm and not thinking through the consequences. Siobhán had very little experience using digital technologies and was very apprehensive from the beginning. She felt she would have a very steep learning curve in using these new computational materials. However, she had taught in England for a number of years and had used a variety of materials with children to investigate design and problem solving issues, so she was confident that she would enjoy working with the materials themselves—it was the programming she feared.

## *Anna in the Empowering Minds Workshops*

### *Fight or Flight?!*

As she approached the computational materials and the Constructionist learning environment, Anna was fraught with tension. On one hand, she was enthusiastic about the potential for the children's learning and wanted to learn all she could, but on the other, she resolutely resisted using the computational materials herself. And her confidence was constantly an issue: each time she seemed to get over a hurdle and develop some real confidence, she crumbled when she faced a new learning situation in which she felt threatened (See Figure 37 and Table 10 below).

*Figure 37:* Timeline illustrating Anna's positive and negative feelings as a series of peaks and troughs (See Table 10 for key to numbered events on this timeline)

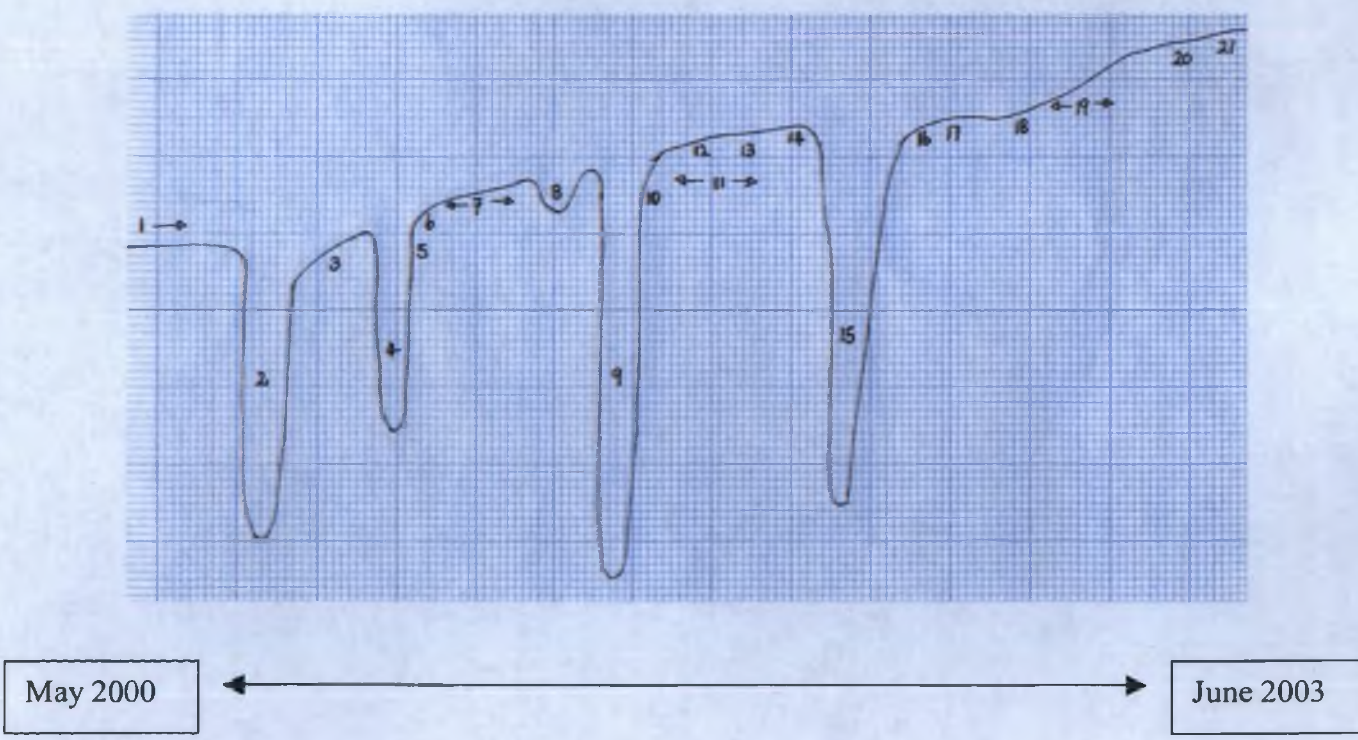


*Table 10: Key to Anna's Peaks and Troughs Timeline*

| KEY EVENTS IN ANNA'S PEAKS AND TROUGHS DEVELOPMENTAL PATTERN | |
|---|---|
| 1 | Enthusiasm prior to first Summer workshop (May – August 2000) |
| 2 | Summer Workshop (August 2000) |
| 3 | Classroom work using the computational materials informed by constructionist principles (Sept.- Nov. 2000) |
| 4 | Preparation for Young Scientist Exhibition (Dec. 2000- Jan. 2001) |
| 5 | Young Scientist Exhibition (Jan. 2001) |
| 6 | Open Night Exhibition (Jan. 2001) |
| 7 | Classroom work using the computational materials informed by constructionist principles (Jan.- April. 2001) |
| 8 | Preparation for EM's Annual Exhibition at which all the schools participate (May – June 2001) |
| 9 | Learning Hubs Summer Institute in Mexico, July 2001 |
| 10 | EM's Summer Workshop (August 2001) |
| 11 | Classroom work, experimenting with Microworlds (Sept – Nov. 2001) |
| 12 | Computer Education Society of Ireland's conference presentation |
| 13 | Attending talks and workshops at Media Lab Europe |
| 14 | Preparation for and attendance at YSE 2002 |
| 15 | Wireless Saga (Jan. –Mar. 2002) |
| 16 | Tasking responsibility for wireless installation problems |
| 17 | Attending various workshops (animation and video editing) and extensive classroom project work |
| 18 | EM Summer Workshop (August 2002) |
| 19 | Classroom Project work (Sept. – Dec. 2002) |
| 20 | YSE 2003 |
| 21 | Member of core group 'think-tank' for EM's expansion |

### *First Summer Workshop (August 2000)*

Anna was immediately frustrated with EM's loose structure; she kept asking where it was leading and what the purpose was of this and that. When asked to try out things and experiment with the computational materials, she was really at a loss. She felt she was wasting time fumbling around, and we would save a lot of time if we would just tell her how to proceed. She was absolutely honest in her negative and hostile response and became intensely annoyed and frustrated because EM did not fit into her preferred way of working:

> It absolutely annoyed me greatly. First of all, because it wasn't organised. . . . Oh yes, there were certain times where I felt absolutely cantankerous that I'd driven to Dublin, and you are wasting my time making me play with this stuff. The kids will play with this stuff—I know they'll want to! Why do I have to play with it? (Interview, May 2002)

Others in the group at the Summer 2000 workshop noticed her strong negative response. Anna herself reports, "Petrina said to me the other day, 'God, you really excel at this, but I remember that you really didn't like it or want to be in it!'" (Conversation, June 2001). Anna is quick to point out, however, that

> I did want to be in it, but I did want to know something. I didn't want to have the discovery learning apply to me. I would fully to subscribe to it for the kids. But I wanted there to be a workshop about a particular item and for me to go to it (Interview, May 2002).

During the first week-long workshop, she continually reminded us that all this was very new material and new ideas for her to deal with, so we should be "telling [her] more about it and how to use it . . . not wasting time, playing with it" (Workshop field notes, August 2000). She was very anxious about returning to school the following week: "How am I going to be able to do this with a class of 35 if I don't know what I'm doing myself?" was her regular rhetorical question for me. At times she was quite vocal and indeed got a little angry, making her feelings known to us in a very determined fashion. She didn't seem to accept that she didn't have to have, nor could she hope to have, all the answers to every problem that might occur and that perhaps the best way of gaining an insight into how the materials could be used was to "play" with them herself.

She appeared to prefer an Instructionist way of working, as she equated "knowing" with "transmission" rather than constructing knowledge for herself. She saw learning as essentially a passive process over which she had no control. She expected "to be told about how to work with the computational materials" in a tightly-structured format that was not her responsibility but was deployed by the course provider. Although Anna eagerly returned again and again to learn more, she believed that this Constructionist way of working was fine for children but not appropriate for her.

### *Why So Resistant?*

Anna's behaviour reminded me of Carl Rogers' theory that we learn only what we perceive as self-enhancing, and only by experience, which we can't have if we feel threatened. In that case, we go rigid and unresponsive, unable to experience and unable to learn (Rogers, 1969). Anna wanted to know about the materials, but rather than get to know them herself, she wanted us to tell her about them, assuming this transmission of information would fast-track her—after all, that's how she'd learned everything up to that point.

So she was unwilling to try a new kind of learning and was quite vocal in voicing her resistance: she stated flatly that she did not need this type of learning experience, and she did not have time for it. She continued to be very impatient with the exploratory learning process and found it painful to engage personally with the materials. She didn't see the point of working through the building process herself and always wanted to short-circuit the process. "Just tell me what to do!" she pleaded, again and again. From previous experience of summer courses or teacher workshops she expected to be told as many of them had focused on the quick-fix or tips-and-tricks approach, whereas our workshop invited her to engage with a wholly different way of learning—for her, a cause for serious concern.

#### *The expected role of a teacher.*

The better I got to know Anna, the more she seemed like a bundle of contradictions. She instantly saw potential in the Constructionist learning environment—for the children—but she did not believe that "playing with the computational materials" would be of any use to her. She did not immediately perceive this way of working as self-enhancement.

Yet she states that she was excited herself when she saw the models move. So what was stopping her creating, and feeling that excitement for herself, at first hand? Could that excitement run contrary to her ideas about what is permissible for a teacher? She seemed to subscribe to the widespread belief that any real teacher should have all the answers. Was it due to societal demands and pressures that she saw herself strictly as a teacher, and not as a learner? I wondered if it was this belief that "teachers teach and students learn" (Kleine-Kracht, 1993, p.393) that was inhibiting not only Anna but also so many other educators from engaging in other forms of learning. I suspected this behavior was so ingrained, she could not allow herself the luxury of the time to experiment, explore and come to know by working with the materials. But still she thought the Constructionist way of working would be invaluable for the children she taught.

#### *Anna and the group dynamic.*

Continuing consistent with Rogers' hypothesis, she felt threatened by interacting within a group. The implied change in self-organisation was just too much for her, and she resisted firmly, becoming more rigid under threat. It prevented her from reaching out and asking for help, which meant she could not capitalise on the distributed diversity of the project group for quite some time.

Rogers concludes that the most significant learning will take place when the perceived threat to the learner's self is reduced to a minimum. We knew it was crucial for Anna to feel supported and safe (Maslow, 1972), as learning and transforming practice involves risk-taking (Zetlin et al. 1998; Mc Laughlin & Talbert, 1993).

*Supportive environment.*

By the end of the week, after much discussion and reassurance that she could call on me or any member of the group if she ran into difficulties, Anna seemed a little happier. She asked me for any notes, work cards, etc., I could give her as she felt that this would help her enormously. Assuming she lacked so many of the requisite skills for introducing these computational materials into the classroom— engineering concepts of building, "the gearing up and down business," the programming—she thought she had to have written materials in order to cope (Discussion, August 2000).

In response to this request, and to demonstrate to her that we wished to provide her with a supportive environment in which she felt her needs were being listened to, I trawled the Internet and the LEGO educational catalogues to locate materials that might be of help to her. Rather than order just the basic building block, I included a variety of building kits to help generate ideas and building plans that she might start with. I also ordered teachers' reference books and follow-up activity materials. (See Appendix C for a full list of these materials). With this safety net in place, Anna felt better able to cope with introducing the materials into her classroom (Conversation, August 2000). We hoped this supportive environment would, in time, help Anna feel less threatened, relax her boundaries, and allow herself to learn in other ways.

*"I can't afford the time."*

For Anna herself to work in the open, exploratory way that we were promoting during the workshops, she would have had to undergo a huge internal organisational change. But she could justify working this way with her students "because kids have what a friend of mine calls 'loads of space in their heads.' They have loads of time" (Conversation, December 2000). Many adults share this sense of children being better able to devote time exclusively to whatever task catches their fancy. How often have you heard adults wistfully say, "Oh, wouldn't it be great to be a kid again and have all the time in the world to devote to one thing?"

Anna explained to me that she likes to know where something is leading: "I can't afford to spend a week fustering around the place. I'd actually like to be shown. . . . [as] underlying everything, I'd be very serious and very driven" (Interview, May 2002). So naturally, when the EM workshop mode ran contrary to her structure and organisation of self, she reacted negatively and went rigid because she felt threatened. She had become accustomed to having a structure that had always been imposed rather than being responsible for deciding on the structure for her own learning. Learning was perceived as being 'out of her control' and she was 'wasting time' if she was not pursuing definite goals prescribed by specified objectives. For Anna, learning meant mastery, not pleasurable, leisurely investigation. She needed time and a supportive climate in order to feel safe enough to relax (Maslow, 1972). The literature points to the need for support at school level that can demonstrate, coach, observe and provide constructive feedback, facilitate networks of learners. (Huberman, 1995; Warren-Little, 1993; Joyce and Showers, 1996). To this end, I visited Anna's classroom regularly to work alongside hers and her students during her first year of involvement with the project.

Although she felt utterly frustrated with the Constructionist style of working, by experiencing it she had begun to extend the framework that shaped her perceptions of herself, her work, and her surroundings because "meaning perspectives are formed through experiences" (Cranton, 1996, p.96). By engaging with the workshops, Anna had discovered and embraced an alternate way of constructing a learning environment for the children she worked with. And she was excited by the prospect: "I could see that they would be interested in it. I remember the excitement that I felt when I saw those models moving at the conference. I knew instantly that they would love it" (Interview, May 2002).

## *Anna Back at School*

### *Teachers Teach—Children Learn*

From her reactions at the summer workshop, it was evident that Anna saw very distinctive roles for herself and her students. She was the teacher; therefore, she thought she should be able to provide all the answers to all the questions, all the time. She felt she had to be in control and manage everything; otherwise, chaos would reign. Knowing all this about her, I wondered if her classroom could accommodate power and control shared by Anna and her students. I imagined a top-down, authoritarian relationship—not necessarily a dictatorship, but a regime more akin to a benevolent despot.

So when I went to visit her classroom (October 2000), I was surprised that she didn't use any of the backup materials (building plans, teacher's guides, etc.) she had claimed to need as a crucial safety net. Instead, she tried faithfully to replicate in her classroom the same Atelier-style approach we had used and encouraged at the summer workshop—even though this way of working did not suit her espoused style of learning. The teachers' notes and manuals that I had sent her were there; in case of an emergency, she could refer to them.

When I asked her what prompted her to work in this Constructionist way, she explained that she and Siobhán had decided together. After the summer workshop, they had discussed at great length what approach they should take. They agreed that as these materials were very new, no one would be surprised if they took a novel approach to their use. Nor were they going to be alone, as both of them would be using the computational materials in their classrooms. They could lean on each other for support. And, like a security blanket, they had the teachers' notes and manuals. They decided that as the project was "forging new ground," they had nothing to lose and would always regret it if they "hadn't given it our best shot" (Conversation, October 2000).

Central to this decision, Anna stresses, was the support from the other teachers and the backup from the project team that had been promised and already demonstrated by the arrival of all the backup and support materials they had requested. She is perfectly consistent, here, with Rosenholtz's (1989) claims that teachers who feel supported in their own ongoing learning and classroom practices are more committed and effective than those who feel isolated and without support. McLaughlin & Talbert (1993) also maintain that support from such teachers' groups and professional communities not only offers "the most effective unit of intervention and powerful opportunity for reform" but that "participation in a professional community . . . supports the risk-taking and struggle entailed in transforming practice" (1993, pp. 18,15).

So both Anna and Siobhán encouraged the children to explore and develop their own ideas and did not influence their direction but gave them total control and responsibility for their own learning. The children were free to build whatever they desired, and Anna tried to facilitate their learning by engaging in deep conversations with them when they had problems. Contrary to expectation, she didn't follow the very structured Yellow Kit approach (i.e., simple building kits accompanied by teacher's notes) although it was very safe and controlled by the teacher, which I thought would have been more in line with Anna's teaching style. Why then did she work in a contradictory style to the one that she displayed at the summer workshop? The way of working that she could not cope with personally was exactly the type of learning environment that she had constructed for her students.

### *The Transformation Begins*

The creativity of the children and their total engagement with the materials encouraged Anna to continue working with the computational materials in a thoroughly Constructionist manner, letting the children find their way, and helping them without directing them. Ironically, Anna was enabled to relinquish control without losing face by the very computational materials that she so strongly resisted engaging with herself: "They expect that I don't know anything about [LEGO construction] because as far as they're concerned, LEGO is for kids, anyway. Why would I know anything about it? (Interview, May 2002)

The changes she saw in her classroom over time caused Anna to reflect and question some of her prior beliefs and assumptions about her own learning. This is consistent with Lindberg's claims (1995) that although belief must underlie a permanent change in human behaviour, belief is most likely to follow behaviour rather than to precede it.

### *Recurring Trend: Highs—and Lows*

A few weeks into her first Constructionist term, everything seemed to be going smoothly and I thought we had ironed out most of the first-stage problems. However, when faced with a new situation in the Constructionist context, Anna felt threatened by not knowing what to do, and she reverted to "I-need-to-know-all-the-answers-now" mode.

#### *Young Scientist Exhibition (January 2000).*

Anna and Siobhán decided to participate in the Young Scientist Exhibition (January 2001), and in the preceding weeks, Anna called me many times, requesting information. She needed precise, minute details about where in the exhibition hall we would be positioned, how long the tables were, how much wall space there was, where the buses would park. If I didn't have an answer, Anna got so agitated and upset that I actually suggested that if participating at the YSE was causing tension and stress, perhaps she might do better to wait until another time when she felt more ready.

I was beginning to realise that when Anna felt she was not in control, her confidence level dropped, and she became consumed by trivialities she could control. She reminded me of a bow, tightly strung and ready to snap at the slightest tug. She was already working on overload because the materials and methods were very different to any of her prior experience. And the magnitude of the event scared her, as YSE is a very high-profile occasion, with plenty of visitors and media coverage. The YSE focuses mainly on second-level schools, so it is not common practice for primary school children like Anna's students to exhibit. And it was her first major public event; she was afraid that the work wouldn't be up to scratch, and that she would not be able to answer people's questions (Conversation, December 2000).

*Product/process contradiction.*

I thought preparation for the YSE event was going to be the straw that broke the camel's back and that Anna would "throw in the towel." But once again, Anna's tenacity about anything she feels is worthwhile came shining through. When they arrived on the day, the children and Anna had done spectacular work and brought with them a range of creative and innovative projects.

During the Christmas vacation, Anna had put an enormous amount of work into preparing display charts. These charts included photographs of the children and their models during the various stages of the building process, and samples of the children's written work describing their models and the process. Anna explained that she had to do this extra work during the Christmas holiday period because "they had run out of time before Christmas, as they just did not realise how much time getting the project together would take" (Conversation, YSE 2001). I suspect that it was also a case of pride as she always likes to put her best foot forward; she must have felt she would let the school down if the display were not up to scratch.

This performance would seem to indicate that she was still very much focused on producing the final product rather than valuing the learning process itself. However, on the day of the YSE exhibition in the RDS, as I observed her talking with people interested in the children's work, she actually focused on the process rather than the final product. She interacted animatedly with these people, telling them how this work had made such a difference to how she worked with the children in school, and how she had come to a new understanding of the potential of digital technologies and what the children were capable of learning. The models, she stressed, were "only the tip of the iceberg" and did not reflect adequately the dialogue, problem-solving and collaborative learning that had gone into producing the concrete artefacts (Field notes, YSE, January 2001).

### *Sharing the Work with the Wider Local Community*

Anna felt their participation at the YSE (January 2001) had been very worthwhile. Inspired and encouraged by the positive feedback, she immediately organised an evening for parents and the local community to see the projects. Her evening was an enormous success, with large numbers from the community turning out for the event. The following day, Anna excitedly told me (January 2001) that it was after 10 p.m. when the last of the parents left the school. Nobody noticed the hours passing as everyone was so absorbed in talking with the children and teachers about their projects.

Buoyed up by these successes, Anna and the children continued to work with the materials, and things returned to a more normal rhythm. I visited Anna's classroom on a regular basis and was intrigued with the fantastic work they were engaged in and Anna's increasing upbeat and confident attitude. Consistent with Tough's findings (1979), she often commented that using the computational materials in a manner that was framed by Constructionist principles resulted in learning being a very pleasurable experience for everyone that contributed to heightened self-esteem. These were important factors in motivating herself and the children to continue working in this way.

### *The Big Event (June 2001)*

Towards the end of the last term in school, we organised an event in the College for all the schools in the project to come together and share the work they were doing. Anna again went through a period of feeling anxious, but it was not as intense. She had a longer lead-time before this event, which perhaps contributed to lowering her anxiety levels. In common with practices she had experienced at the teacher workshops, she left the choice of theme and its development entirely within the learners' control. After lengthy negotiation, the children finally decided to explore life in ancient Egypt.

To begin their investigations, they travelled to Dublin to visit the museums and to purchase some research books with funds Anna allocated from a project budget. She was especially impressed by her students' seriousness, and she told me that they remained immersed and totally engaged at all stages of the project. For example, when choosing their reference books, they weighed the merits of each book carefully, compared them, and justified each choice. When she saw how earnestly and maturely the children engaged with their chosen theme, Anna resolved to give them more control over their own learning (Conversation, April 2001). The children eagerly told me (Classroom visit, May 2001) that they had consulted all types of media (books, videos, CD-ROMs and Internet sites) in an effort to "get to grips with what life was really like in ancient Egypt" so that they could build "authentic models" using the computational materials, which they skilfully combined with other materials (clay, craft materials, painting) to depict Egyptian life. On the day of the event itself, Anna was relaxed and confident, animatedly discussing the value of using such expressive computational materials for learning.

Looking back over her first year, Anna commented that she values the importance of participating in such events and is no longer frightened of them. They are now no longer something new and threatening but something she can take in her stride. She no longer felt "she was being judged as a teacher" but saw these events as "occasions to celebrate and share the learning process" (Conversation, June 2001).

Taking cognisance of Lindberg's claim that belief is most likely to follow behaviour (Lindberg, 1995) rather than to precede it, I was sure Anna had turned a corner and would now be more open and relaxed when it came to her own learning, and perhaps more willing to engage emotionally with the computational materials. Siobhán's and her decision to design a Constructionist-learning environment for her students had been the first step. I believed this action would be instrumental in prompting self-directed questioning of her beliefs about learning, particularly her own willingness to engage with unfamiliar learning experiences.

Her actions had been coupled with the supportive environment of the EM community, who had also negotiated official release days with the NCTE, and she was encouraged to visit other classrooms across the project schools. Anna remarked to me that only when she visited some of the other teachers' classrooms did she understand that they weren't "any better" than she, and that everyone had their own way of working with the materials. She felt encouraged to continue, and reassured that she was not in a competitive environment but that EM really was emphasising "collaboration and helping each other" (Conversation, December 2000).

So toward the end of her first year, Anna's confidence and self-esteem were high, and she committed to attending the first Learning Hubs Summer Institute (http://ii.media.mit.edu/) to be held in Mexico (July, 2001). I explained to her that this Summer Institute would be very much focused along the some principles as the EM summer workshop that she had so much trouble with. Anna firmly assured me that her views had changed as a result of her classroom experiences over the school year. She believed that she was now ready for this new learning experience. She was, in fact, quite looking forward to it (Conversation, June 2001). In turn, I was fully aware that belief must underlie a permanent change in human behaviour (Lindberg, 1995), but I thought Anna had at least begun the process of questioning her existing beliefs and assumptions.

### *The Summer Institute (Mexico, July 2001)*

Anna not only sacrificed over 2 weeks of her summer vacation but also contributed in excess of €1200 herself toward the cost of the trip. She looked forward to the trip, and I felt she would develop a lot personally as she seemed more relaxed and positive towards the Constructionist philosophy. Conscious of the importance of understanding participants' expectations (Tannenbaum et al., 1991) and to avoid misconceptions, I stressed repeatedly to Anna that the Summer Institute would be organised very much along the same principles as our own summer workshop (August 2000) but with a greater variety of technologies so that people could pick and choose themselves what they wanted to pursue in depth.

We discussed at length the different types of computational materials and topics of interests that were proposed, and Anna seemed to be earnestly looking forward to the Summer Institute. However, once there, she found it extremely hard to cope with the emergent design, admitting later that "The Mexico workshops absolutely annoyed me from the same point of view" (Interview, May 2002), referring to the Constructionist approach we had taken at the previous summer's workshop. In Mexico, despite expectations, she regressed to her former tense and frustrated self.

Although she seemed to have accepted a process-oriented way of working with the children in her classroom, Anna still had very different assumptions about what a learning environment should offer her. In the classroom she seemed to accept that there was an intimate connection between knowledge and activity with problem solving being a central process. The design and organisational structures of the classroom learning environment encouraged collaboration amongst learners as they constructed their negotiated projects using expressive computational materials. The biggest implication for the context of learning is that this context was a 'social' one. In relation to how she understands the children's learning this shifts Anna from a view of knowledge as an object to something that was not just a process but also a participatory construction process. In common with the Empiricist and Rationalist traditions, when it came to her own learning, Anna viewed knowledge as an object, with learning being the absorption of a given set of facts and procedures, whereas "the constructive view of knowledge implies that learning depends on the learner's activity" (Bolhuis & Voeten, 2004, p.78). According to social learning theory (Bandura, 1986) and self-regulation theorists (Zimmerman et al., 1996), learning is a social rather than an individual phenomenon. What we value as knowledge shapes our understanding of what learning is and colours how we expect learning environments to be structured. Anna expected external regulation—to be told what she was to learn and how she was to learn it—rather than to be active in her own learning process. This contradicts Cranton's claim that "the essence of professional development for educators" (1996, p.116) is a self-directed process of continual questioning and revision of perspectives on practice. Anna did not believe that she should set her own learning goals. So, consistent with Rogers' theories (1969), she again went rigid and resisted a learning environment that challenged her well-established expectations of what learning should be.

She spoke to me about her frustrations on a number of occasions during our first week in Mexico. Initially, she complained bitterly that "there was a lot of time being wasted during the workshops with people being left to their own devices with no direction as to what to do" (Conversation, July 2001). Knowing she needed support, I explained that what seemed to her to be a waste of time in the morning was actually time for her to devote to working on her own projects. This schedule was also logistically necessary, as our hotel was quite a distance from the Telemex building in which the institute was being held, and the bus schedule was complicated. Most people enjoyed their freedom to organise their own routines, but Anna got quite angry, and after a few days, had a chat with David Cavallo, the Summer Institute's chief facilitator, who also explained to her the rationale behind the arrangements. Anna stated that she prefers "very structured activity . . . with particular events and topics timetabled at definite times which weren't changed at the last minute" (July 2001). This is perhaps why she found it so difficult to cope with the responsibility of arranging her own time. For Anna, "structured activity" meant a structure designed by someone other than herself. Just as she had done in the previous summer workshop, she found it difficult to understand the principle that learning could be self-structured, or that the responsibility for learning might rest with the learner.

From these episodes it would appear as if Anna had not changed at all in her outlook since the first EM summer workshop. But with support and constant reassurance from other facilitators and myself, as well as the other teachers from the EM group, Anna calmed down after the first week. Although she participated in a number of discussions and workshops, I noticed that she didn't really settle down to anything in depth, preferring to work alone or with Siobhán on occasion, rather than becoming involved with others to work on a project—in other words, a complete re-run of her first summer workshop. I realised then that, contrary to my earlier belief that Anna had turned a corner, she wouldn't be comfortable with this style of learning for herself for a long time, if ever.

Anna's contradictory behaviour in the classroom and at teacher workshops continued to puzzle me. She designed a process orientated learning environment for her students and expected them to be self-directing but she strongly resisted this type of learning environment for herself. Huber and Roth (1999) present evidence that the ability to respond to the demands of self-directed learning, including self-regulation and the active construction of knowledge in social learning situations, differs according to the learner's tolerance of uncertainty. Bolhuis and Voeten (2004) claim that a lower level of uncertainty tends to accompany more traditional conceptions (i.e. with a preference for external regulation, for the reproductive knowledge conception, for the individual learning conception and the more static conception of intelligence). Perhaps Anna wasn't able to engage with the process-orientated workshops because they had such a high uncertainty level. But the stimulating learning environment Anna designed for her students contradicts other research indicating that teachers with a low tolerance of uncertainty are less able to create learning situations that truly stimulate self-directed learning (Huber & Roth, 1999).

I realised that quite often there are distinctions between teachers' conceptions of student learning and their own learning. Bolhuis and Voeten found that teachers can tolerate much more uncertainty in student learning than in their own learning (2004, p.96). Perhaps teachers themselves need more structured support in their learning process (Huber & Roth 1999). If teachers are to move toward self-direction in learning, they need a program that is sensitive to their contradictions and that offers flexible supportive structures capable of responding to individual needs.

### *Revelations: How Anna Learns*

#### *The personal touch.*

In Mexico, Anna declined invitations from other teachers to work collaboratively, saying that she preferred to work alone. She remarked to me that she works better on her own initially until she feels comfortable enough to ask questions. Working in a group, she said, she "feels under pressure." She emphasised that she feels "everyone else knows so much more" than she does, so she "gets flustered, can't focus and then gets left behind". Consequently she "finds it very difficult to ask questions" if she "doesn't understand something, particularly if it is someone she doesn't know well" (Interview May 2002).

*Figure 38:* Anna in Conversation with South American Teachers on the Steps of the Pyramid of the Moon

Although she felt angry and uncomfortable with the open, collaborative style workshops, the conflict helped her reflect on how she learns, what is important for her and what conditions promote her own development. Upon reflection, Anna realised that before she can ask for help from others, she needs to know them well on a personal level and to have built up a bond of trust with them. Anna needs to connect socially, to know as much as she can about others' backgrounds and ideas. While she was in Mexico, although she did not settle down to work on any concrete project in depth, she did interact and talk at length to a wide range of participants. She is still in contact with a number of these people by email, particularly Ann from Venezuela, with whom she formed a great friendship (See Figure 38 above).

*Never judge a book by its cover.*

Although Anna cannot approach someone unless she knows them well, she comes across as a very talkative, confident individual when you first meet her. From her strong, proactive approach to getting her school into Empowering Minds, I thought Anna was very much a self-starter who could act on her own initiative and would be very comfortable and proactive with others in the group in order to further her own development. However, as I came to know her, I began to see that she is in fact quite shy and needs to feel very secure with someone before she will approach them for help. The initial approach to becoming involved with the project was easy for her because she believed in the exciting learning experiences working with these computational materials could offer the children in her classroom.

> Even though I [am] confident and outgoing on a one-to-one basis, I came to life as an extremely shy person, and anybody who would see me as an adult would find it hard to believe that all the way up through secondary school, I did not speak to anyone, that I was extremely shy, and that is me, on one level. I would find it very hard to insert myself into a group. My head would be down. So I would find it very hard to approach a group and say "How do you do this?" especially a group of, say, three or four (Interview, May 2002).

If my involvement with Anna had been just the typical once-off workshop with no structured follow-up or supportive climate for learning, I never would have known Anna well enough to realise that behind her vocal negative reaction was an acute lack of confidence. In a collaborative learning environment, she felt insecure and vulnerable—all the more so in an atmosphere of uncertainty such as the Atelier style of working: "that's why I would have found that too open a course. Intimidating except you knew loads of people…" (Interview May 2002).

Naturally enough, Anna conceived her ideas about her own learning as a teacher over many years of experience with other teacher inservice or professional development courses. Most of these experiences were typically informed by the "Knowledge for Practice" conceptualisation (Cochran-Smith & Lytle, 1999), which is characterised as a disciplines approach. Adherents to this model assume that there is a body of subject-specific theoretical and pedagogical knowledge, that teachers should possess, and that teaching is the act of putting this knowledge into practice. Teachers are consequently perceived as "knowledge users" rather than as "knowledge producers." Closely tied to the Empiricist understanding of knowledge, there is generally a "standards-based" (student achievement and/or teacher competencies) approach to school reform. Teachers are seen as passive consumers of research and as a consequence, transfer of training became a goal for in-service programmes. 'Theory, demonstration, and practice' training design dominates this type of staff development programmes (Joyce and Showers, 1980). Never having experienced any other type of inservice, Anna came to expect this model, where she did not feel threatened as she did not have to engage with others.

In retrospect it is easy to understand how the participatory nature of EM workshops naturally caused turmoil for Anna as she found it difficult to interact with others. Forming meaningful relationships with people is important to her before she can begin to collaborate on a shared learning experience. We encouraged teachers to get to know each other better by organising smaller cluster meetings and encouraging visits to one another's schools. But being faced with a totally new situation and a new group of people in Mexico was just too threatening for Anna. She regressed, closed down, and retreated back into herself, unable to open up to this new learning situation.

As she got to know people, though, Anna found herself able to approach them: "Obviously the people I would know better are the ones that I've communicated with. I'd know them better and I'd feel that I could go to them" (Interview May 2002). She came to value the social gatherings we had after the more focused group meetings and workshops, and always made a point of thanking us for organising these events. She also relished visiting other teachers and working with them in their classrooms. She believes that her specific difficulties are resolving due to the strong personal relationships she has built up over time. Now, she can approach someone she knows well without feeling threatened; she is open to working with him or her to resolve the problem she is interested in.

*Language to break into a group.*

> When you know something yourself . . . it appears as if it's very simple, and to everybody else who doesn't know the terms, it appears as if it's

> rocket science. I wanted to get in, but I didn't have the language (Interview May 2002).

Anna realises that, apart from her own personal difficulty dealing with groups, this language barrier also slowed her down. She acknowledges that she feels insecure and inadequate when someone has more experience than she has. But she also knows that, given time, "you build up the 'common' language and the ability to communicate your needs" (Classroom conversation, March 2002). Anna appears to be beginning to understand "the notion of community of practice [which is] . . . characterised by the shared practices, (linguistic) conventions, behaviour, standards of ethics, viewpoints etc." (Roth, 1999, p.16). Signs of self-management and self-direction (Candy, 1991) are also emerging as she realises that it is up to each individual to ask questions and build their own understandings—which, of course, is very hard for her unless she knows the person or group very well: "if I don't know the person I would find it very hard to make the breakthrough to get in" (Interview May 2002).

*Identifying with a group.*

Anna feels that the Summer Institute was a very worthwhile experience because she learned so much about herself and how she relates to others. Besides gaining a valuable awareness of other computational materials that she later began to use, she established firm, personal relationships with the other teachers in the Empowering Minds project (Siobhán, Ursula, Tom, Seán and Donal). She knows this small group well, often referring to them as "the Mexico crew," and feels comfortable exchanging classroom experiences and asking them for help when problems or difficulties arise. She'll say, "If I have a problem, I'd go to Cathal because I'd know him from Mexico," or "Now, Ursula—we've had contact with her because we know her from Mexico," and "I did want to get into using the video camera. I eventually got in with John Kelly but that was only because I would have known him from Mexico" (Interview May 2002).

Also thanks to this personal connection, she made her first response to a general query on the group mailing list, in response to Tom's enquiry about problems with laptop batteries: "Tom Murphy emailed the group one night about the Compaq battery . . . and then another night about the laptop, but I emailed him back, saying that I thought it was Cathal that had had the problem with the laptop" (Interview, May 2002). This personal connection has increased Anna's sense of responsibility for what's happening outside her own classrooms and has established an allegiance to the group.

Feeling part of a group and acting accordingly, however, are difficult for teachers, as they generally perceive that they must "stand alone" to guard the "legendary autonomy" of teachers in the Irish education system (OECD 1991). When teachers hold such strong beliefs of professional autonomy and identity, they often perceive seeking the co-operation and collaboration of colleagues as a weakness rather than strength and a willingness to learn (Sugrue, 1996; 1997). Asking for help can often be interpreted as weakness or failure, and as a signal that a teacher is unable to cope, a death knell in the culture of competition that has developed in schools. Owing to school organisation and architecture, teachers have come to feel responsible for nothing outside the four walls of their own classrooms. Those who do take an interest in the actions of others are fearful that their interest will be interpreted as interference.

We infer these feelings from Anna's statement about her first response to a query on the mailing list:

> I emailed him back, saying that I thought it was Cathal that had had the problem with the laptop . . . even though it wasn't really my business. . . . I felt that he was a real person out there and that I would respond. Whereas if I hadn't actually spoken to him, I would have thought, "Well, whoever it was who had the problem would contact him.'" (My emphasis; interview, May 2002)

*Demystifying others.*

The power of getting to know people on a personal level also helps to demystify them. Knowing people personally helps to dispel the impressions you have created that can often be the barriers to communication.

> The night in Glorianna's, I had a long conversation with [a colleague] . . . and she was telling me what was happening in her personal life, like we sort of touched base. And I thought, "Oh my God, life can be tough!" . . . And the same night I had one of those same conversations with [another colleague] as well. Again, that probably de-mystified him as well. He was talking very straight and openly (Interview, May 2002).

This social gathering in Mexico (June 2001) was the moment Anna first felt that she was beginning to know others in the group, not as fellow teachers but as "real people": "Again, it's the personal contact, it's not the actual [materials] contact. The person comes first and then you get talking to them about [the materials and classroom work]" (Interview May 2002).

Only when people get to know each other well do stereotypical images, or assumptions, or impressions break down. Often when we have the opportunity to get to know people, we realise that our understanding of particular individuals was misinformed because of fleeting first impressions.

> Before we went to Glorianna's everybody . . . was saying [male teacher] was up in lights and in capital letters. Well, definitely had we not gone … we wouldn't have approached [him] because he would have thought that we were eejits who knew nothing and that he was this great big genius way ahead of us. You would imagine that we would be more intelligent and more thinking than that. That sort of seems to be the reality. I suppose when time is short, you go to people that you know. . . . Going to Glorianna's demystified [that teacher]" (Interview, May 2002).

#### *Teachers are people too*

Anna stresses getting to know the personal side of the group members because, after all, "You're a person rather than a teacher" (Interview May 2002). Many teachers feel that they are not seen as people, but that they have a teacher persona they must put on for the world in order not to lose face. This reminds me of an image from "The Love Song of J. Alfred Prufrock"[7] (T.S. Elliot, 1917), which captures how so many people lack honesty in interaction with others for fear of losing face: "To prepare a face to meet the faces that you meet." (T.S. Elliot[8]). Teachers often feel they are supposed to know "everything," and they worry they will lose face if they ask for help. So teachers need time and the opportunity to build trust among themselves, in order to feel secure in reaching out to ask for help and support. The image of the teacher as "the knower of all things" is ingrained within our society and it will take a long time to wear down or change. Many believe that the only legitimate use of a teacher's time is standing in front of the class, working directly with students (Hord, 1997, p.18). We need a paradigm shift, both in the public and in teachers themselves, about the role of teacher.

### ***Reversal of Outlook***

#### *Decrease in anxiety/ increase in openness to learning.*

At her second EM summer workshop in August 2001, Anna was noticeably less anxious about scheduling, and engaged with a range of activities that were of most interest to her. She didn't feel that she had to "get the flavour" of everything as she did in Mexico. She was comfortable working at her own pace, no longer feeling threatened

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[7] http://www.bartleby.com/198/1.html
[8] http://www.bartleby.com/people/Eliot-Th.html

by "others rushing ahead." Rather than refraining from "playing around" with the computational materials, this time she wholeheartedly got involved. She earnestly tried making sensors, asking for help when she needed it rather than getting annoyed and frustrated.

She was particularly interested in the digital camera as a way of capturing the learning process within her classroom. She was very happy with the way Glorianna Davenport worked with them individually first, talking through many aspects of their pictures, and then brought everyone together for a group discussion focusing on imagery and storytelling.

*Figure 39:* Anna and Student Collaborating during Summer Workshop

Anna was beginning to feel more comfortable with her own learning style, realising when she needed help and being able to ask for it (See Figure 39 above). She wouldn't have this valuable insight if she had been involved in a typical teacher-development, one-shot workshop, which Corcoran (1995) maintains are generally a waste of time as they lack a clear focus and effective follow-up, and more important, they are not part of a more long-range scheme of learning for teachers (Corcoran, 1995; Floden, Goerttz & O'Day, 1995). Anna grew because she was immersed for an adequate period of time (Raywid, 1993) in a supportive group who engaged in reflective thinking and collaborative inquiry (Darling-Hammond, 1996; Hamilton and Richardson, 1995). In a learning culture where differences and individual needs and interests were accepted and respected (Sugrue et al., 2001; Grossman & Wineburg, 2001), she felt supported in her ongoing learning and classroom practice (Rosenholtz, 1989) and had the confidence to initiate change (Showers & Joyce, 1996).

### *Coping with the unexpected.*

In contrast to the obsessive, controlling individual who had to know down to the last detail what was involved in an upcoming event, and who would have been devastated if the projects were not complete or in perfect working order, Anna now loves the challenge of working with the children towards an event. She eagerly volunteers to participate without getting stressed over the minute details that would previously have been uppermost in her mind.

She gets a "buzz" now, working towards a deadline rather than feeling anxious and uptight. The children have voluntarily stayed behind in school on several occasions to work on their projects. Anna was so engrossed with the projects, she often stayed on in school long after the children had gone home:

> I love the fun of it. The real life working of it. Say, the end of the year project: you are working to a deadline. I loved that. There was one night I went home from school at five to twelve" (Interview, May 2002).

Going home near midnight is totally out of character for Anna as she normally retires at ten each night.

She now also appreciates that she can't control everything and that some things are completely out of anyone's control. She realises this flexibility is more reflective of everyday life, and that she has to take it in her stride:

> Last year [YSE 2001], something happened to the printer, and the same this year [YSE 2002]. So probably if you were working in an office, which I have never experienced—say, an arts studio or advertising studio—you would have a deadline, and you'd have to work up against that deadline. And that kind of deadline was sort of real-time working" (Interview, May 2002).

Although she feels this type of work is closely related to "real time working," the deadline isn't everything to her, as she now values the learning process more than the finished product. She can see the benefits of children sharing works in progress, and is prepared now to bring along work to exhibitions to share with others that is not complete. Looking back over the first year Anna commented that she values the importance of participating in such events and is no longer frightened or apprehensive of them. They are now no longer something new and threatening but something that could be taken in her stride. She no longer felt "she was being judged as a teacher" but saw these events as "occasions to celebrate and share the learning process" (Conversation, June 2001).

*Children taking control and altering relationships.*

Anna feels enormously encouraged now that she does not have to constantly control and monitor everything. She has realised that the children are quite capable of controlling their own learning and taking responsibility for it, as well.

> The day that the project came together for me was when there was a group of them at the computer, [and] Christopher said to me, "We're not going to be ready in time. What are we going to do about it? How are we going to manage?" It was the way that he was taking responsibility, that he had taken ownership of it. . . . Then they were saying to me, "Can we stay back [to work on the project] tomorrow?" They were holding me back in school rather than me holding them back" (Interview, May 2002).

Anna realises that responsibilities have shifted; she's working in partnership with the children, which alters their interaction with her and with each other: "Now it's us and we're doing it. . . . I like that because I don't know everything" (Interview, May 2002). She is free of the heavy obligation to know everything and she is now "genuinely not threatened by them knowing more about the LEGO" than she does (Interview, May 2002). Nor does she feel that she must have a huge personal interest in what each child is pursuing as

> They can have their own interests . . . and it's nice if they can soar in their own areas and soar in what they are interested in. . . . I absolutely love when they find out something new. Now I don't feel that I should be interested in everything they're finding out because I'm not living their life. I'm living my own life, but part of my own life is being fascinated by how they work and what they are interested in" (Interview, May 2002).

She strongly believes that her students' learning success is closely linked to changes she has made in her classroom practice (Guskey, 1986) and their progress has been the major factor, which has sustained her interest in remaining as part of the project group.

> It's them, 100%. . . . To me, it's interesting, watching them. And I think that it's a very valuable project. I think that they get loads out of it, but I also always get loads out of it (Interview, May 2002).

Anna now understands learning as a reciprocal relationship in which both the teacher and the students benefit and gain from one another—a far cry from Anna's original assumptions about who does what, in teaching and learning.

### *Working in a Group*

At a group meeting in October 2001, the EM teachers who had been to Mexico suggested that Microworlds was worthwhile using with the children. The rest of the group were interested in finding our more about this software, so the "Mexico crew" got together to organise a workshop.

Anna had told me during a school visit in her first year (March 2001) that she would find it impossible to communicate with someone remotely if she did not know them personally. "It's all very well," she told me, "to say 'Email!' but you can't very well email unless you actually know the person." Now, though, after the Summer Institute, Anna knew the "Mexico Crew" very well. She realised that this small, geographically disparate group who were planning a Microworlds workshop would absolutely need to use email. The phone wouldn't be adequate as they had to share Microworlds project files. Besides, in order to plan effectively, each member of the small group had to be party to all of the discussions. Email consequently was the most effective tool they had at their disposal for what they were trying to achieve.

Anna began working with her children using Microworlds. When she ran into difficulties and needed help, she communicated with Seán by email. What ensued is a typical example of an individual teacher's learning supported by peer-to-peer interaction. Consistent with the Vygotskian zone of proximal development (1978), Anna was facilitated in her learning by a more able peer. Seán had progressed more with the Microworlds in Mexico, so she felt he would be able to help her out. She believed Seán would understand her difficulties best of all the Mexico crew, as he was also a newcomer to using Logo. He was just that little bit more knowledgeable than she was, and would be able to help her without "blinding her with science." Via email, Seán enabled her to continue working on the animation projects with the children. She commented regularly that she hadn't realised she had learned so much at the Summer Institute, and was now able to make sense of the more advanced work some of the rest of the group had done (Classroom visit, November 2001). She was really pleased with this realisation, and motivated to move on and explore new ideas using the Microworlds software.

***Taking a Risk: The "Diver"***

Now that she felt more secure and safe, Anna was not so preoccupied with getting things right from the beginning but was willing take risks as she now had other members of the group to whom she could turn to for help—perfectly consistent with McLaughlin & Talbert's observation that "participation in a professional community. . . supports the risk-taking and struggle entailed in transforming practice" (1993, p.15). The group members had always been there, but now Anna felt able to ask for help, as she knew some of them well on a personal basis. However, she didn't turn to peers for help immediately, but always tried to work through problems with the children first. Otherwise, she realised, they would never grow in their own learning and ability to tackle a problem. She was confident in the knowledge that help was there when and if they needed it, she only had to ask.

When the children's first efforts with their "Diver" claymation was a bit jerky, she talked with them about what the cause could be. As they examined each picture closely, they realised that they had changed the camera angle or height each time they had taken a shot. With this new insight, they decided to correct this the next time by using a tripod to ensure that the camera remained in the same position for each shot. She talked to me about this discovery (November 2001) and at a group meeting (December 2001), and a short time later she voluntarily demonstrated the jerky, imperfect first attempt, explaining to the group how it led to an important discovery about using the camera. Prior to this, the group had only seen ever finished products from Anna, not a work in progress, warts and all. She was now willing to show work that wasn't quite perfect—a complete reversal of her earlier anxious, perfectionist position—and what she previously considered disasters, she now views as learning opportunities to be carefully examined and debugged.

Her shift towards valuing process equally with product became evident during the second year of her involvement with the project. No longer compelled to know everything about the materials, Anna was freer to observe and note the children's activities and ways of learning, particularly how they were interacting with one another when they run into difficulties. We saw her new emphasis on observation of the learning process in her increasing contributions to group meetings, her conversations with me, and her spontaneous emails to let me know about classroom developments. For example, she noted that the children were using their knowledge of mathematics to help them in their constructions: "'She needs to move through 180, not 360,' one child remarked as they were trying to construct a model of the game show, 'The Weakest Link'" (Interview, May 2002).

### ***Participating with the Group to Share with Others***

Anna took a risk when she volunteered to come and help facilitate a workshop at the CESI (Computer Education Society of Ireland) conference (November 2001). Before, she would have felt out of her league, but now she felt ready to share her experiences with others. She brought along the current work her children in class were doing, and she was not in the least perturbed that much of it was not finished. The unfinished work would be a bonus, she believed, as it would highlight the process as important, not just the finished product. Whereas seeing a finished product would she felt be putting the emphasis on traditional values of focusing exclusively on the product. She wanted to emphasize computational materials' potential to externalise the children's thinking so changes in their thinking could be observed over time. For moral support and also in recognition of the fact that the children knew more about using these materials than she did, she brought along her son, who had worked with the materials during the previous year, to help her answer questions.

#### *Young Scientist Exhibition (January 2002).*

Anna's preparation for Young Scientist Exhibition (January 2002) was a complete reversal to that of the previous year. There were no panicky phone calls or emails. She was completely flexible about which day to attend, once she had enough notice to arrange a change of date with the bus hire company. As the exhibition organisers were changing the usual format, I knew very little about the display area. But Anna was relaxed and not worried in the least about the exhibition area. She remarked casually that she could work around whatever was available. Because she was focused on process rather than product, and as a result of her experiences at workshops and in class, she could now tolerate more uncertainty, and be flexible and adaptive.

#### *Group support enables risk-taking.*

Anna believes that a supportive community made trying out new things and taking risks easier (McLaughlin & Talbert, 1993; Darling-Hammond, 1996; Hamilton & Richardson, 1995): "If it was within the project it would be a safe thing to do because you'd have someone else if things went wrong for you so . . . it would be like, 'Let's all jump together!'" (Interview May 2002) She feels that when she has some else to work with and try things out with, the emphasis moves to collaboration rather competition, so she is less anxious and able to learn about learning because she is not focused on the product but can engage with the process. Just as the children have often referred to EM learning as "hard fun," Anna has found that "learning about learning" has been challenging. When she faced her own assumptions and came to new understandings about learning, the overwhelming feedback and enthusiasm from the children and the feeling that she was making a difference to their learning (Guskey, 1986) provided Anna with her equivalent of the children's sense of "hard fun":

> What I'm interested in is what it brings to the classroom, the atmosphere it brings, . . . the buzz, really. I'm part of the buzz. I'm not out of the buzz. . . . . I'm interested in going into work every day. I enjoy it, I get a buzz from it" (Interview, May 2002).

### *Tentative Breakthrough to the Main Group: "My Voice is Heard!"*

Anna's group-interaction style change started with a new software package. When Anna introduced Microworlds to the children in her class and saw how interested they were in using it, she encouraged them to explore it in whatever way they wished. She was amazed at how quickly they began making their own projects. When she saw an animation workshop advertised at the ARK (cultural centre for children, located in Dublin City Centre, approximately 20 miles from Anna's school), she thought this workshop would broaden the children's and her own experiences, and fuel ideas for working with Microworlds. She booked a session at the ARK in March 2002, then sent me email with details about these workshops, asking me to let the rest of the group know, as she thought it might be of interest to them.

When I rang her and suggested that she send the mail to the group, her reply was that she felt "it would be better coming from you as I wouldn't want to be telling others what to do" (Conversation, February 2002). Although she was beginning to feel more confident sharing ideas with her children, the "Mexican crew," and me, she still felt hesitant about sharing ideas with the entire EM group even when she knew in her heart they were good ideas. But when I reassured her it was a wonderful idea and thanked her for letting me know about it, she felt confident enough to email the EM group herself. She had now crossed another hurdle and although she continued to mail me personally about various things she observed in her classroom, she also began sending mail to the group mailing list.

Support and positive feedback again were key in helping Anna develop the confidence to take another step forward and play an active part within the EM group.

She has come to realise "that everybody's opinions . . . matter to the group [and] that everybody would be valued in their own way" (Interview, May 2002).

*The value of being heard.*

Being part of the group is now very important to Anna as she understands each person's expectations are valued and accommodated through mutual planning (Tannenbaum et al., 1991). She values the collaborative planning process for their learning (Freire, 1970) and points to the different workshops, hardware and materials that have been organised in response to different requests as evidence that everyone's opinions are listened to and respected:

> The main thing is that we actually have an input . . . and that our views are listened to, and what happens then is modified based on what we've said. Whereas that doesn't normally happen with teacher in-service—you get to make your comments on the last day, and then it doesn't matter anyway because it's finished" (Interview, May 2002).

Anna pointed out that rather than a "surface friendliness" (Grossman & Wineburg, 2001), there was an open, respectful ethos within the EM community. So rather than feeling coerced and subject to "group think," she felt liberated and empowered (Sugrue et al., 2001, p.39). In fact, just being heard and able to voice an opinion was sometimes all she needed:

> [It's] not even [about] control, but that you have an input . . . because if you discuss it and the discussion goes against you, then at least you have the satisfaction of saying your piece. Sometimes that's actually all you needed, to say your piece and get it off your chest (Interview, May 2002).

Here is a huge breakthrough, a complete turnaround from when Anna felt so out of control, tense, and frustrated in the early days of her involvement in the project.

*Promoting diversity.*

Anna acknowledges the value of a group to bounce ideas around with because they can provide a variety of perspectives and help her understand something from a different angle: "When you hear someone else say, 'Well, actually, no. You're wrong,' you then modify what you thought because somebody that you respect said no. Or they might bring up a point that you hadn't though of" (Interview, May 2002).

The rationale for developing a community is rooted in support and cultivation of teacher learning (McLaughlin & Talbert, 1999; Cochran-Smith & Lytle, 1999; Nelson

& Hammerman, 1996). But it is paramount that the membership of learning communities is as wide and diverse as possible, as the learning community is maximised when people from multiple constituencies work together collaboratively and continually (Louis & Kruse, 1995). Extending the membership of professional communities beyond classrooms and school campuses has demonstrated that this is a powerful form of teacher learning (Darling-Hammond & Mc Laughlin, 1995; Wood, 1995). This diversity across a community also contributes to "enhancing their capacity to create things they really want to create" (Senge, in O'Neill, 1995, p.20). What was important to Anna was that the EM group was not made up exclusively of teachers (Warren-Little, 1993, p.138) as she thinks that "swimming in the same pool all the time is just dreadful"(Interview, May 2002) and welcomes EM's opportunity for development rather than striving for consensus (Warren-Little, 1993, p.139) only to end in inevitable mediocrity.

#### *The group as conscience.*

Anna values the group's help and support, as it has encouraged her to take risks, thereby spurring her on to new learning opportunities: "I think it's great, . . . that you have the group to gee you up and to support you" (Interview, May 2002). She points out that the group has another role, too: "They're sort of your conscience. You can't sort of suddenly pull out for no reason. . . . [T]hey know you, and that you're out there. Somebody is going to say 'Where were you?'" (Interview, May 2002).

I'm intrigued by Anna's reference to the other members of the group as her "conscience." Working in a Constructionist way, she believes, is much more difficult for a teacher as it requires much more time, effort and attention that traditional methods. It is a real challenge to engage in meaningful and authentic learning with a diverse group of children on a daily basis. Sometimes it would be much easier to lapse into old habits, but the group is there with its dual function to remind her of what can be and also as a support to help her continue. Belonging to a group, then, is a two-way relationship: they are there when she needs them for help and support. They are concerned for her well-being, and each individual member—including Anna—also has a personal role to play and responsibilities to live up to within the group.

### *Classroom Connectivity*

#### *Taking responsibility.*

As Anna began to absorb the group dynamic, she was eager to reach beyond the classroom walls to communicate with others. Group meetings and other forms of face-to-face contact were limited by distance and time constraints. Electronic communication was a possibility now that the entire group knew each other well but would be a problem unless we could arrange connectivity in each of the teacher's classrooms. Although she had found it so difficult to reach out to the group in the beginning, she was in fact one of the strongest advocates for trying to get classroom connectivity. She had "become ready to learn those things [she] need[ed] to know and be able to do in order to cope effectively with real-life situations" (Knowles, 1998, p.67).

#### *Excitement and anticipation.*

Anna saw so many possibilities and valued this wireless initiative so much that she persuaded the principal to reallocate some of the school computers to her classroom. She also got him to promise to buy extra USB client adapters in order to have more than just the laptop with the wireless card available for the classroom Internet connection. Anna was so excited at the prospect of connectivity in the classroom that she constantly talked about it and brought it up at every opportunity. She was impatient because it was taking so long. Here is the timeline:

- End of August 2001 workshop: We all agreed classroom connectivity was a priority as a platform for communication in the next academic year.
- September 2001: We applied to the HEA for funding for the wireless initiative from the collaborative research fund between Irish Universities and Colleges, and Media Lab Europe.
- October/ November 2001: The HEA funding proposal deadline was extended, but we went ahead with field testing of various equipment to find the most suitable hardware for wireless connectivity in schools.
- December 2001: The HEA funding proposal was approved.
- January 2002: We ordered equipment.
- Last week in February: Installation—finally begins —after delayed delivery of equipment

*Frustration and denial.*

I could understand Anna's frustration as six months passed after our decision to try the wireless option for connectivity, and still she could see no concrete signs of it materialising in her classroom. Even though I explained to her that the best-laid plans still are subject to Murphy's Law, she was getting increasingly frustrated as each week slipped by with no apparent developments on the wireless installation. Anna had built herself and everyone at the school up so much that she was bitterly disappointed at each delay in installation.

When the wireless hardware was finally installed (March 2002) and it didn't work, Anna was devastated. On the phone, she was so angry and upset that she could not listen to reason. Everyone was to blame—the technician was incompetent, installing a product they knew nothing about—she went on and on. This was not what I had come to expect from Anna. She had developed such a positive attitude to learning with her students in the classroom and had been open to trying so many new ideas that I expected her to see seen these setbacks as learning opportunities, and engage wholeheartedly in finding a solution. I tried to suggest that this initial failure with equipment often happened when trying out new hardware and that it generally took some time before it was operational. I suggested that this was a wonderful problem-solving situation and if we approached it in a positive way we could perhaps be more successful in finding out what the problem might be.

But Anna was very negative and felt it was not her responsibility, as the technician installing the hardware should know what he was doing. Again, I explained that all networks were different, and that no one simple solution could work for every situation, but she was not engaging with me. She reacted as she had at the first workshop, saying quite vehemently that she didn't want to be "messing about with networks as someone else should know what to do" (Telephone conversation, March 2002. She would accept no responsibility for finding a solution to the problem. Even though many of the other schools were experiencing difficulties with the wireless hardware, she could see only her own school's predicament. She was focused on just one part of the larger problem of finding out how this equipment worked—only on her own school's situation.

Unless she could see the big picture—the problems we were having at all the other schools—she would remain part of the problem rather than part of the solution. If she engaged with the problem and tried to understand the larger picture, she might possibly help find a pattern or a connection that linked all the difficulties across the project schools. But Anna allowed her lack of knowledge about the technical workings of networks to fuel her fear, paralysing her ability to engage with the learning opportunity in this problem.

*Turmoil.*

Anna's response was so forceful that it set me thinking about why she should react in this way. I wondered how this situation was different from the other new experiences (e.g., Microworlds, video editing) that she had dealt with so positively lately. Perhaps she was more negative and aggressive because to understand the wireless installation, she had to have some knowledge of networks, but she knew absolutely nothing about them. She desperately wanted connectivity in the classroom because she now prioritised sharing and communication as something that was paramount to her own and the children's learning. With these conflicting emotions and her lack of knowledge, she must have felt powerless in the situation and its solution, especially as the principal regarded the network installation as his exclusive personal domain and would not allow her to deal directly with the installers. Bearing these factors in mind and recognising her fear, I thought I might be able to support Anna by helping her understand some principles about networking and what could possibly be causing the lack of connectivity.

*Information and interest.*

We decided that I would try to find out more from the technician, and Anna and I would talk again soon. I discovered an array of problems: the equipment that was to be installed wasn't the original equipment that we had tested with, as it was no longer available; the technician who had done the field-testing was not doing the installations, as he had left the company; no notes from the original testing had been passed on to the new technician, so effectively she was starting with a clean slate; her expertise was in software installations on networks, not hardware, so this was a new learning experience for her too; nor had she prior experience of working in schools, as she had come fresh from the corporate section of the company. The networks she knew best were large client-server type, not peer-to-peer or web-ramp, which are common in the schools.

All in all, it looked like a recipe for disaster. I was frustrated, too, as I had spent many months researching the options, field testing, negotiating budgets and so on, and now the prospect of it coming together looked very bleak indeed. Talking with the technician, I thought the problem could be the web ramp and not the WAP itself because the laptops could see the network but could not access the Internet. When I explained all the background factors to Anna and told her that we thought we might have a possible solution, she brightened up and became more optimistic and proactive.

#### *Taking action.*

Anna enlisted the help of the principal, as he was responsible for the network, and she knew that she would need his support and buy-in if we were to solve the problem. Using the laptop with the wireless card to communicate with the network, they successfully printed a test page on the printer in the lab. This strengthened our hunch about the web ramp security settings. The principal, however, remained unconvinced, but Anna persisted in finding out (through the principal) from the company whether security settings had been originally set.

The principal reported that the installation company insisted that no security settings had been set and that the WAP was at fault. In the meantime, the *eircom* technician had continued installations at some of the other schools, but everyone was experiencing problems, and no one had connectivity. The group mailing list now became the vehicle for keeping everyone informed, and the teachers began to discuss what they thought could be the problem at each site. At this point, the person with whom I negotiated the installation, who was responsible for overseeing the technician's work, suggested terminating the initiative, saying "Let's undo all the installs to date, give the equipment back to the supplier, and forget the whole thing" (Telephone conversation, April 2002).

I, however, was not about to give in. Although the contractor at the telecommunications company was looking for the easy way out, I insisted that we had a contract and that connectivity was possible, but that we would have to work together if we were to solve the problem. He was not convinced. By sharing these developments with the teachers, I demonstrated to them that I was willing to commit wholeheartedly to trying to solve a problem that they had expressed as very important to them.

Consistent with the literature on adult learning (Lindeman, 1926) the teachers understood that their needs were being treated seriously and they too rose to the challenge of finding a solution to the wireless problem. As Carl Rogers (1969) suggests this learning was personally meaningful and relevant, so they were "ready to learn those things they need to know and be able to do in order to cope effectively with real-life situations" (Knowles, 1998, p.67). They began to share a collective responsibility for their common problem.

### *Identification with the group problem.*

Anna's principal remained certain that his network was fine and that it was the WAP installation that was faulty. Anna, however, was not willing to be so easily dissuaded. She did not give up hope, but rather than continuing to be annoyed and negative, she empathised strongly with what she saw as my difficulties with the contractor and the other schools' problems. She was able to step outside her own school environment and her own problems, and to have some appreciation of the bigger picture. She was curious about what was happening in the other schools and what problems they were experiencing. She tried to understand what was going on and relate it to her own situation.

I encouraged the group to email the group mailing list to keep everyone informed of developments, so the group would enjoy solidarity as they realised they were not alone in having problems with the wireless hardware, which might move us toward a solution to the problem, as a pattern might emerge.

Anna was very understanding and encouraged at this stage. Finally, when I had called in another company to fit a router in one of the schools so that they could use the WAP, we discovered that the cat5 cable had been wired backwards. When the rewiring solution worked in another school, we knew we had a definite breakthrough. Anna was so delighted with the prospect of connectivity that she spent a day helping the technician in the school despite the fact that she was on her Easter vacation.

The support of telephone calls from myself coupled with the regular communication through e-mail with the group helped Anna realise that she was not alone in trying to solve a problem that was important to her. It empowered Anna to take an active role in solving the connectivity problem at her school and to understand that it was the group's interactions and sharing of ideas that ultimately lead to the solution of the problem.

### *Broadening Horizons: A European Perspective*

Motivated by the exciting developments in her classroom, Anna participated in a European project [9](organised by Hugh Gash and myself) to share her work with the children, using this new set of computational materials. She and her students eagerly created a project to share with partner schools in France, Austria, Germany, the Czech republic and Hungary. As a direct consequence, her interest in French has been renewed and she has begun to take French classes, which she shares with her students. Through this project, she has widened her sphere of collaboration and is receiving very positive feedback about the work she and her students are doing, which reinforces her new way of working and encourages her to continue. She and the children are widening their understandings of different cultures and bringing a variety of perspectives into the overall project.

### *Appetite for Learning*

Now, Anna is insatiable: she confidently soaks up as many learning opportunities as she can. Not only does she attend all our own group meetings and workshops, she also goes to outside events that she feels will advance both her own and her students' learning. She has taken a keen interest in activities at MLE[10] and has attended some talks there (e.g., David Cavallo[11], and Mitchell Resnick[12]) as well as a video-shooting and -editing workshop with Glorianna Davenport[13] and the world-renowned filmmaker, Ricky Leacock.[14]

She is also attempting to do things that previously she was not confident in pursuing. During her Easter vacation in 2002, she signed up for a teachers' workshop that the ARK[15] (the cultural centre for children, located in Dublin city) were running as part of the programme organised in conjunction with Todd Machover's[16] work with the children's orchestra. This series of workshops focused on exploring and using some of the musical instruments developed by Todd's group at the MIT Media Lab. Despite her initial comment, "I'm not at all musical," Anna signed up for these workshops, as she no longer feels that she has to excel in order to learn.

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[9] www.europeanprimaryvillage.org
[10] www.medialabeurope.org
[11] http://learning.media.mit.edu/people.html
[12] http://web.media.mit.edu/~mres/
[13] http://ic.media.mit.edu/people/gid/
[14] http://www.richardleacock.com/
[15] http://www.ark.ie/culture/html/home.html
[16] http://web.media.mit.edu/~tod/

During her Easter vacation (March 2002), in addition to the music workshops, she also voluntarily attended a 20-hour video-editing workshop organised by our own group even though she received no formal credit or reimbursement. In addition to her time and travel expense (about 50 miles, round-trip), she paid a fee to participate in the music workshop.

These are but a few examples of Anna's willingness to try new experiences and to learn more about using digital technologies for her personal and professional development. And she now shares her experiences in a free and open, honest way that enables herself and the children to continue learning. She is learning with and alongside her students and is enjoying their learning together.

## Anna Reflects

### What is Learning?

Asked if she has changed her definition of learning over the time of the project, Anna replies:

> Oh, very much. Very much. Without any doubt. Absolutely, without any doubt. That year that I did that computer course in Maynooth, when I started reading about Seymour and all that sort of thing, I thought that it was absolute madness. . . . If the Lego project didn't come along when it did, I might have forgotten all about Seymour Papert and all the importance of his theories. I'd say it would have been just more background. (Interview, May 2002)

Here, she's illustrating exactly what so often happens with one-shot inservice if it is not tied to a teacher's daily practice, or grounded in what is important to them: "It would have been just more background"—she would have filed it and forgotten it. Teachers' existing beliefs and attitudes are firmly rooted in and moulded by past experiences, and unless directly challenged in an ongoing way, their understandings of learning and the daily life of the classroom will remain unchanged, whereas change in behaviour will often lead to a change in belief (Lindberg, 1995).

The design of the EM learning environment took explicit account of the contexts of teaching and the experiences of teachers, giving Anna a way to relate new ideas directly to her individual and institutional history, practice and circumstances (Warren-Little, 1993, p. 139). Using her classroom experiences as "an object to think with" (Papert, 1980), Anna began to reflect upon her existing beliefs and assumptions about learning, thus challenging the context-independent or "one-size-fits-all" mode of staff development that delivers standardized content to individuals whose teaching experience, expertise and settings vary widely (Warren-Little, 1993, p. 139).

Anna has now come to a different understanding of what learning can be for her and for the children she works with. This change happened so slowly over time that Anna "would find it hard to pinpoint but I think . . . there's no going back. It's like another row of knitting—you don't appear to be getting very far, but suddenly, it's a jumper!" (Interview, May 2002)

### *Enough Time to See the Links*

Her new understanding of learning, particularly Papert's theory of Constructionism, ripened only when she saw the ideas in action; only when the computational materials had concretised and externalised the ideas for her, did Anna understand Papert. The process took considerable time and was constantly reinforced by the feedback cycle of Anna trying things out in the classroom and attempting to make sense of what she had read and was experiencing as the children engaged enthusiastically with the materials and the learning goals they had set for themselves:

> It did take me awhile to see [the links]. I would think it's perfect sense now. When I started reading it [Mindstorms] first I thought it was absolute madness. . . . I don't know how long afterwards, but it was afterwards I fitted it in with what I knew, and I made sense out of it from what I knew. . . . I think I saw more of what he was talking about when I was working through the project with the kids. The project, definitely; I had bought into it a bit from what I'd read, having dismissed it first of all as total nonsense. Then I sort of bought into it from what I knew already but then, when the project came. . . . Now, it couldn't be any other way. So it's gone from low to very high (Interview, May 2002).

Huberman recognises the need for adequate time to allow for development of ideas: "Neither clarity of practical understanding nor appreciation of the significance of an innovation fully develop until teachers have gained some experience in trying it out in their own classrooms" (1995, p. 249). In the four years of her involvement with the EM community, Anna has realised that there is "an extra dimension" to working with the computational materials; they have opened up windows into the learning processes of the children. Anna is now adopting a Constructionist approach in other work with the children besides the "LEGO" project:

> Since I've got into the project, I have sort of copped the idea that kids learn better by linking things. So the Constructionism of the [materials] really swayed me. I'm trying more as I go on, especially . . . to try and

> make links. Like last year, instead of doing things chapter by chapter, which I would have done, say, four or five years ago. I marked the tops of corresponding chapters and did those together and tried to link it more" (Interview, May 2002).

Rather than being continually preoccupied with teaching and having to be in control, orchestrating everything that goes on in the classroom, Anna now feels that she has more time to observe and absorb what's going on as the children actively pursue their own learning tasks and goals.

> When they are actually [working] . . . I would be more of an observer, rather than when I'd actually be teaching a lesson. . . . With the kids, I've a policy now of not telling them what to do and that's special for me, its great freedom for me. I've said to them, "It's your project. I'm not meant to know everything about it." They don't think that I'm any less of a teacher because I don't know (Interview, May 2002).

### *Changing Relationships: "He's Delighted With Himself!"*

Anna avows that the Constructionist approach to learning and using expressive computational materials "does change the relationship with the class for some kids. It's mind-boggling, really" (Interview, May 2002). She feels that the children are drawn to these materials because "you can actually programme and get this thing to do exactly what you want it to do" (Interview, May 2002). She often reports to the group that working with these materials has been "a huge dimension" in the lives of many children, particularly those who normally did not shine in a more traditional classroom.

For one particular boy, who described himself as "a geek . . . with no friends," the project has made "an amazing difference in his life":

> Because he's good at the actual building . . . good in the eyes of the other kids. They'd say, "How did you do that?" "How did you get that to work?" He's got great ideas, and they're calling him, rather than ignoring him and leaving him in the corner. And he's gone back to the hurling because he's back in with lads. He's delighted with himself (Interview, May 2002).

When a new girl, very quiet and shy, "joined the class, it gave her a way of talking to people." Many incidents just like these galvanised Anna's belief in these computational materials and the Constructionist way of working with the children. She passionately believes that if it is the means by which "you can . . . make people feel that they belong, it's worth it" (Interview, May 2002).

## *Conclusion*

Constantly on the lookout now for different learning opportunities for herself and her students, going to the animation, music and video-editing workshops, Anna is becoming fully independent and self-directed in her learning (Candy, 1991; Cranton, 1996); she no longer sees only classroom-bound learning experiences, but she also looks beyond the walls to outside experiences and influences. She lets her students' interests set the agenda, and she no longer feels that she has to have all the answers.

I myself am encouraged to continue when I see Anna working in this way. I think back to her initial insecurity and apprehension about using the Mindstorms materials with her class, when she wanted to be told all about how to use them and how she felt she couldn't do it unless she had lots of backup materials. How very apprehensive she was, and anxious, needing constant reassurance that she really didn't have to have all the answers as long as she was willing to work alongside the children, be open, and help them work on their problems. She amazed me when she didn't work in a very controlled and rigid way with the children but let them build freely and be challenged by their own designs and interests.

Obviously encouraged by how well the first year of working in this way had succeeded, when it came to using the new Microworlds software, she was very relaxed about introducing it to the children although she herself did not have a lot of experience working with it. She was very enthusiastic about the possibilities of what could be done with this software as, in Mexico, she had seen a wonderful variety of innovative and creative projects developed using Microworlds. She was amazed at how quickly the children adapted to working with the software: "They produced in a little space of time things that I didn't produce in the two weeks in Mexico. . . . They were able to do it. Probably because I have fear, and they don't" (Interview, May 2002).

Fear of taking a chance, reluctance to work in a new way, and an inability to reach out for help or work collaboratively in a group—all these obstacles initially prevented Anna from engaging with these expressive computational materials in a Constructionist learning environment. However, over time (Floden, Goerttz & O'Day, 1995; Guskey, 1986; Huberman, 1995; Caperton & Papert 1999) and with supportive feedback and encouragement (Showers & Joyce, 1996; Darling-Hammond, 1996; Caccia, 1996; Raywid, 1993; Ruiz et al., 1995), she has begun to change. Working with others in the group, she now understands there is no fixed way of doing things as everyone works in different ways. So she has reflected on her learning style and those of the children in her own classroom. She realises that talking about doing things initially doesn't work for her; to get a grip on new experience, she needs to try it out for herself. Once she has built up her own initial understanding, then she can ask questions and look at other people's work. Because she needs time on her own when she is trying to learn something, she no longer feels the need to be in total control of all learning that takes place in her classroom. She now recognises that children can learn on their own, in a range of very different ways, if they are given enough time and space, and the appropriate supportive environment. No longer feeling threatened by "not keeping up with some of the others in the group" also keeps Anna happy to learn at her own pace, in her own way. So now, in her classroom, she gives the children the time and freedom to explore the computational materials and develop their own projects at their own pace. Anna is very comfortable with the fact that quite a few of the children know far more than she does about how to use the computational materials. Rather than interpreting this as a "failure" on her part, she regards this as an asset that helps other children as they develop their projects.

Given the time and space to develop in her own way within the group, she values the respect that she's given as an individual, so she makes a point of respecting the individuality and differences among her students. She realises that she does not—and need not—have all the answers, and she is very comfortable working with the children in this way. For example, at a group meeting when the teachers were sharing the projects their classes were working on, Anna showed an animation some boys had developed about how easily a fight could break out in the cloakroom. One of the other teachers asked how they had taken such professional-looking photographs and how they had imported the pictures into Microworlds. Anna confidently answered that the children had used a tripod with the Sony Mavica camera to avoid the jerkiness of the photographs in the Diver animation. However, she explained that she would have to ask the boys how they imported the images, as she didn't know how they did it. She promised to email the group an explanation of their method. Formerly so insecure about the limits of her knowledge, Anna now felt safe enough within the group to make this admission (Maslow, 1972). She is very comfortable with the idea that the children know a lot more about certain things than she does but that she can help them out with other issues.

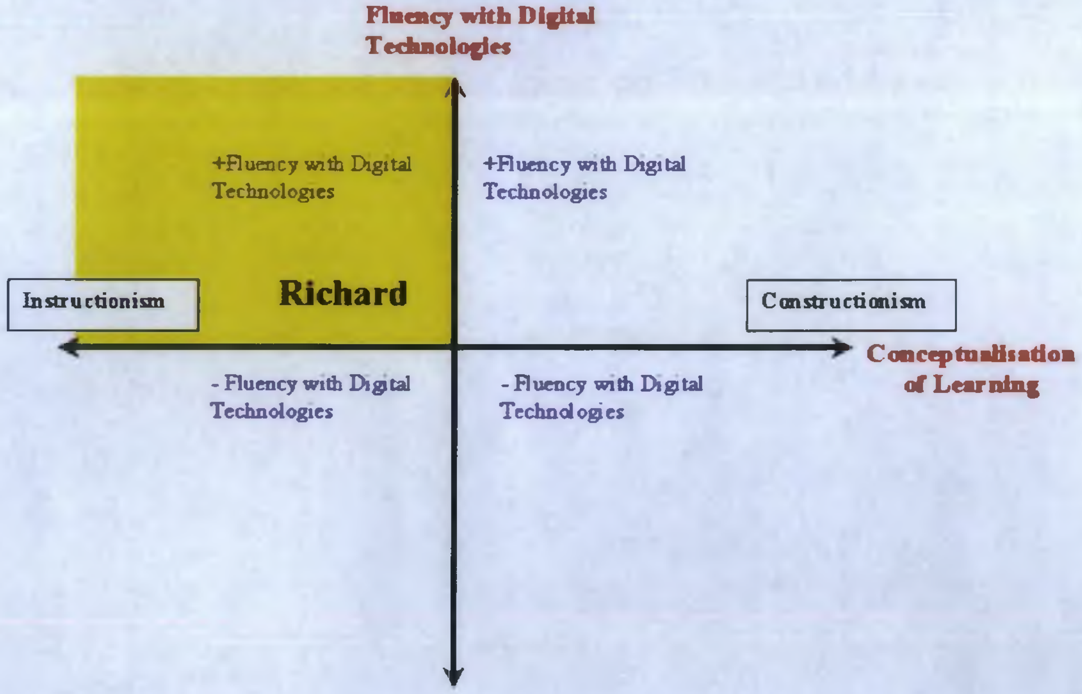
Anna is so energised by her new outlook and understanding of what being digital can mean for learning that she is part of the core group of project teachers (approximately 14) who are actively involved in designing workshops and support group structures for other teachers who have expressed an interest in using computational materials. This initiative is being funded and supported by the NCTE and the initial phase of development took place at six education centres nationwide from February to December 2003. This is substantial evidence for promoting the EM model of teacher learning as it has "significant consequences for capacity building within the system" (Sugrue et al. 2001, p1). Anna had never been a workshop facilitator for adults before. Though she used to find it difficult to work with people she did not know well, she was willing to risk this new venture in order to "spread the gospel" about how empowering this type of learning has been for her own development.

Anna has also begun questioning existing school practices and curriculum (Warren-Little, 1993, p.139). This is consistent with the work of Rosenholtz (1989), who maintains that teachers who feel supported in their own ongoing learning and classroom practice are more committed and effective than those who feel isolated and without support. Within her own school, for example, she has suggested to the school principal (Conversation, February 2003) that perhaps the remaining officially allocated release days for the school staff should focus on examining the philosophy underpinning the national revised curriculum rather than planning how the curriculum should be implemented in their school. She believes this focus shift could start a process within the school that would lead to a learning culture like Empowering Minds. Just four years ago, she was so concerned about "not having all the answers" that she felt she could not work with these computational materials in her classroom, didn't see why she should, and did not feel comfortable asking anyone for help. Anna now believes that her involvement with the Empowering Minds group has enabled her to grow in confidence (Darling-Hammond, 1996; Hamilton & Richardson, 1995), change her classroom practice, and evolve into a self-determined learner.

# Case Study 3: Richard
## *The Drill Sergeant*

> One of the worst things we do in our schools is compartmentalise. We cut things in bits. One of the worst cuts we make is dividing the aesthetic from the knowledge, from the science. This is a disaster, because the source of the children's energy is very largely in . . . their social relations and their aesthetic drive. This is what produces the energy—and we cut this off (Papert, 1990, p.9).

*Figure 40:* Richard: Digitally Sophisticated, Traditional Teacher/Learner




### *Introducing Richard*

Richard is confident, self-assured and has been using digital technologies to augment his teaching since the mid-80s. Technically minded, he is a keen sailor, with his own boat that he maintains and races competitively in his leisure time pursuit.

With the exception of a year's career break, which he spent teaching a multi-grade class of boys and girls in a rural Welsh primary school, Richard has spent 18 of his 28 teaching years in a large primary school with 32 teachers, located in an affluent suburban area just a few miles from the city centre. Most of his students have been middle and upper primary school children, aged eight to twelve years. He always had taught them chiefly with textbooks, making little use of concrete materials.

A dedicated teacher who is regarded as competent and highly successful by colleagues and the students' parents, Richard likes his classroom orderly and under his control. He is not comfortable with open-ended tasks, preferring activities that are directed to the achievement of prescribed curriculum objectives.

## Richard's History with Computers

Richard has been interested in computers in education since 1985. Early on, he brought his own BBC model B computer into class each day in a rucksack, as the school did not have any computers. Since then, he has actively pursued this interest by selecting the Computers in Education option in his Bachelor of Education degree in 1985-87. In addition, he has attended several courses in computing, including skills-based courses, maintenance courses and a twelve-week programming course. From 1998 to date, he has been a tutor for the ICT skills courses developed by the NCTE and the INTO, so he has lots of experience working with other teachers as "the expert" course deliverer.

Richard's school is comparatively progressive in its approach to the use of digital technologies, as it has had a dedicated computer lab with approximately twenty computers since 1996, and staff agreed to release one teacher to organise and manage this lab.

For most of the staff and children, the provision of a dedicated computer lab and resource teachers was an improvement, as they were now going to be using technology on a regular basis. For Richard, though, it meant that his use of technology moved out of the classroom; his students' technology use became a neatly packaged activity that took place in an hour-long session per class twice monthly. He worked closely with the computer resource teacher to plan these sessions; prior to and after each session, he structured classwork that related closely to the work they did in the computer lab. Richard was comfortable with this arrangement as now each child was getting a definite computer time slot without the timetabling and rota difficulties he had with just one computer in the classroom. Most of his software was curriculum-reinforcement packages with some adventure or simulation type-games such as Crystal Rain Forest and Map Detectives. Richard sums up his attitude to using technology prior to his involvement in the EM project as follows:

> I viewed technology as a tool to be used in enhancing my teaching. I was using a prescribed curriculum and felt the computer could assist the child in acquiring mastery of the objectives I wanted them to learn. I had product driven expectations and put a high emphasis on knowledge recall (Richard's Master's Dissertation, June 2003, p.49).

## How Richard and Empowering Minds Came Together

Terry, the computer resource teacher, applied to the NCTE under the SIP initiative to fund a project in his own school. When he heard about Empowering Minds, he was very interested in becoming involved. He had been a dedicated Logo supporter during the 80s and still did some programming with the children. With such a large staff to choose from, Terry had no problem filling the EM team requirements (two classroom teachers, one male and one female each teaching a different grade level; one with little of no experience of technology and the other with a strong comfort level). Richard was a natural choice as he was adept with digital technologies and had worked closely with Terry in the past, delivering teacher inservice courses on technology use. Richard was interested in EM as it seemed to offer a novel way of using technology, and a source of interesting materials for his class. As the project initially was funded for just one year, he saw it as a short-term commitment that would not interfere much with his general classroom practice.

## Choice of Partner

With Richard aboard, Terry recruited a female teacher who had no prior experience of using digital technologies but who was open to Constructionist ideas. Despite feeling very insecure, she knew she needed to become computer literate, so when Richard and Terry assured her of their support, she agreed to participate. These three teachers formed part of the original group of nine teachers who volunteered their involvement in the first phase of the EM project group (March 1999- June 2000).

## Richard in the EM Workshops

### Richard's Starting Point: The Influence of Prior Experience

As the project commenced, Richard's teaching mostly fitted the descriptors Brooks and Brooks (1993) outline as characteristic of a traditional classroom:

- Curriculum is presented part-to-whole with emphasis on basic skills.
- Strict adherence to fixed curriculum is highly valued.
- Curricular activities rely heavily on textbooks and workbooks.
- Students are viewed as blank slates onto which information is etched by the teacher.
- Teachers behave in a didactic manner, disseminating information to students.

- Teachers seek correct answers to validate student learning.
- Students primarily work alone

(Brooks & Brooks, 1993, p.17).

Richard recalls that "I did not see myself as a learner in the classroom. A major assumption of mine was that my role was one of being the disseminator of knowledge, leading and guiding the work in the classroom" (Richard's Master's dissertation, June 2003, p.41). EM challenged his beliefs and changed the ways he used "technology, and understood learning" (Richard's Master's dissertation, 2003 p.51), causing him "to reflect on my role in the process" and inspiring"me to make significant changes in my teaching methodology" (Richard's Master's dissertation, 2003 p.35).

Rogers (1969) hypothesises that we tend to resist experience that involves a change in the organisation of self, and that our structure and organisation of self appear more rigid when we feel threatened; we relax our boundaries only when the threat is reduced or disappears. From the beginning, the influence of prior experiences coloured Richard's reaction to the materials and to the Atelier style of working. He had worked in the UK's educational system that favoured a project-based approach and emphasised a range of materials. Coming from a whole-class method of teaching with a heavy emphasis on didactic pedagogy, and remembering his work in Wales as supremely frustrating, Richard had a hard time adapting to a style of working that grouped children to work on a number of tasks simultaneously. During our early conversations at workshops, he recalled his work in Wales frequently, always saying that he could see nothing much being achieved there but "lots of kids running around with hot-glue guns" (Discussion, August 1999).

On his return to Ireland, Richard had reverted back to his comfort zone of whole-class didactic teaching, where he got "results" and affirmation from parents and colleagues as a good teacher. He told the EM group "there would *have* to be some structure and organisation of what activities had to be done [in a Constructionist classroom]; otherwise, parents and other teachers could say that we were just all fooling around and playing with LEGO" (Discussion, August 1999). Such firm structuring was necessary, he believed, in order to avoid the chaotic scenario he had experienced in the UK and "be confident that the children were actually working on particular tasks and learning something" (Observation, August 1999).

### *The First Workshops (Easter and Summer 1999)*

> Holding components in my hands that I had never seen before challenged me, as I had no idea what to do with them . . . [and] . . . I did not know what was expected of me in this course. My previous experience of inservice courses was in direct contrast, insofar as I always knew what to expect and how I would be treated. On other courses, the content was set out and delivered by an expert. I was a passive learner and expected to have developed certain pre-defined skills by the end of the course. To be left to explore and investigate [made me] apprehensive about how I was going to work with these materials in my classroom (Richard's Master's Dissertation, June 2003, p.52).

Richard further developed his construction skills at the second workshop and was feeling elated at his achievements, but he still "would have been happy if someone had shown me a solution as this was my previous experience of learning through direct teaching" (Richard's Master's Dissertation, June 2003, p.52). During the 1999 summer workshop, he frequently insisted that work with these materials *required* specific prerequisite skills, which the children needed to develop before building models of their own design. Having a "high level of mastery" was important to Richard because he was accustomed as a teacher to being considered "the expert". It would be hard and personally threatening for him to break out of this mould (Cranton, 1996) particularly as it meant a reorganisation of self (Rogers, 1969). He had difficulties with the construction of his models and felt he needed to have some background to understand more clearly the concepts of gearing, levers, pulleys, building ratios, etc.

> I was comfortable with the programming element but very unsure of my construction skills. I ...thought I would have to learn a lot myself before engaging with it in the classroom (Richard's Master's Dissertation, June 2003, p.53).

Other teachers also said they felt inadequate about construction principles too, and thought it would be a great help to have some sort of guidebook for the process. In an effort to allay their fears and help them feel more secure about working with the materials, I investigated the range of LEGO Dacta materials and chose a set of four simple building kits ("Yellow Kits," for the box color) accompanied by teachers' guides, which dealt with the principles of gears, wheels, levers and pulleys. Richard made thorough use of his Yellow Kit when he got back to class.

In the early EM workshops, Richard struggled to control the activities with these computational materials. He made his preference for a very specific focus abundantly clear in the "story theme" discussion:

> The group discussed what we might do in our classrooms and the consensus reached was to base the project on the theme of Story, Myth and Legend. I was in opposition to this choice as I considered it was very open and undefined. . . . I proposed the building of space vehicles, or a space theme. . . . The group convinced me that . . . Story, Myth and Legend would allow me to pursue a space-based story or theme if I wished. . . . As we left this course, I was both anxious and uncomfortable, . . .worried about how I was going to organise the equipment, timetable the lessons and learn more myself about basic construction techniques (Richard's Master's Dissertation, June 2003, p.53).

Evidently, his workshop experiences and prior experiences of working with materials in the UK intensified Richard's natural tendency towards order and compartmentalisation.

## *Richard Back at School*

### *Boot Camp!*

In the 1999 EM summer workshop, we spent lots of time discussing various ways of organising the materials, with the teachers themselves sorting the pieces into various categories. But on his return to school, Richard did not give his students the same opportunities to familiarise themselves with the computational materials. Even though the workshops were non-prescriptive and encouraged collaboration and open exploration with the materials to facilitate deep learning experiences, Richard did not structure his classroom to reflect the learning conditions he had experienced himself. He tried to dictate every detail, every aspect, from the organisation of the materials to the groups the children worked in, to the range of building activities and projects they worked on. The children had no freedom to make the learning experience their own.

#### *Organisation of the materials.*

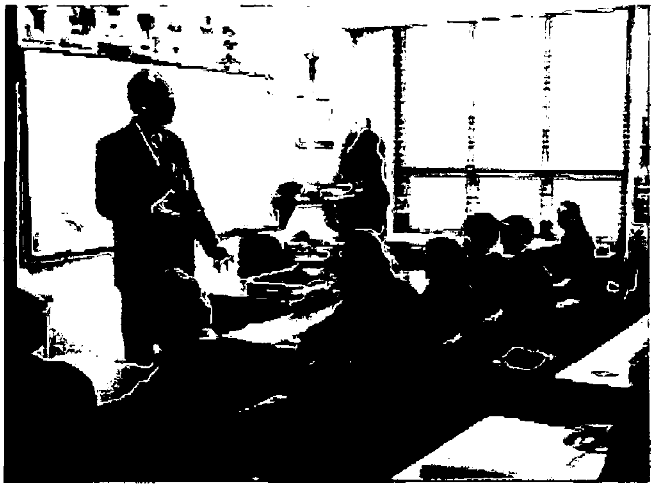
From the beginning, Richard

> decided the class would sort the component parts and store them in labelled containers. Using a sheet with component names to sort the parts, I labelled containers accordingly, and then I had the children sort the parts. Here again, I didn't give the children much freedom, as I insisted on having things organised as I thought best" (Richard's Master's Dissertation, June 2003, p.54).

He further indulged his compulsion to compartmentalise the EM project work by insisting the school management buy a special lockable cupboard for this new equipment, ostensibly because others using the room for after school activities would interfere with the materials. But the press was also a convenient way to indicate to the children that project work was over until the next session. By having the materials out of sight, I continued with my class teaching, safe in the knowledge that I was finished with project work for a while" (Richard's Master's Dissertation, June 2003, p.54).

### *Children's groupings and classroom organisation.*

*Figure 41: Classroom organisation prior to building session*



Richard's classroom was traditionally arranged in straight rows of tables and chairs all facing towards the front of the classroom (See Figure 41). But for each of the skills-building sessions, dedicated to gaining an understanding of gearing, pulleys, wheels and levers Richard organised the children into groups of four and rearranged the classroom furniture. These groups resembled nothing so much as an assembly line in a factory, with everyone doing the same planned exercise at the same time, having received a tray with the required parts for the exercise and a copy of the building instructions (See Figure 42 below).

The classroom was also regimented, with set procedures for how the materials were organised, who had permission to select pieces, and how the materials were to be put away afterwards (Observation notes, Classroom visits, September—December 1999).

> The containers were placed on a row of tables at the front of the class rather like a buffet style. In each group a person was appointed as a 'gopher' to bring a tray and select parts as if selecting food in a self-service restaurant. No other person was permitted to get parts, as I wanted to avoid having too many children wandering around the room. At the end of lessons the person in charge of the materials would replace the unused parts in the containers and lock the materials and models into the press (Richard's Master's Dissertation, June 2003, p.55).

*Figure 42:* Selecting materials from the buffet

Though this level of control appears stifling, during my visits, I saw the children immensely enjoy working with the materials because they were completely different from the usual business of school (Observation notes, September to December 1999).

### *Timetabling.*

Unlike the workshop sessions that allowed the teachers to work for several hours at a stretch to develop their projects, Richard timetabled a series of lessons for one- hour slots on three different days. Most of the teachers organised extended blocks of time, which often ran to more than three hours per week—e.g., two hours in an afternoon with a continuation of the building activity the following morning, which maximised the time available as there was only one set up and clean up session. Richard, however,

> needed to feel I could manage the sessions . . . [and] thought that longer periods could lead to discipline problems for me as I would find it more difficult to control what everyone was doing. I was also concerned that if I spent any longer in the week at this work, other subject areas would suffer. . . . I felt pressurised to make time for the various curriculum subjects and was conscious that my two colleagues teaching the same class level were advancing through textbooks and I was behind in this work" (Richard's Master's Dissertation, June 2003, p.58).

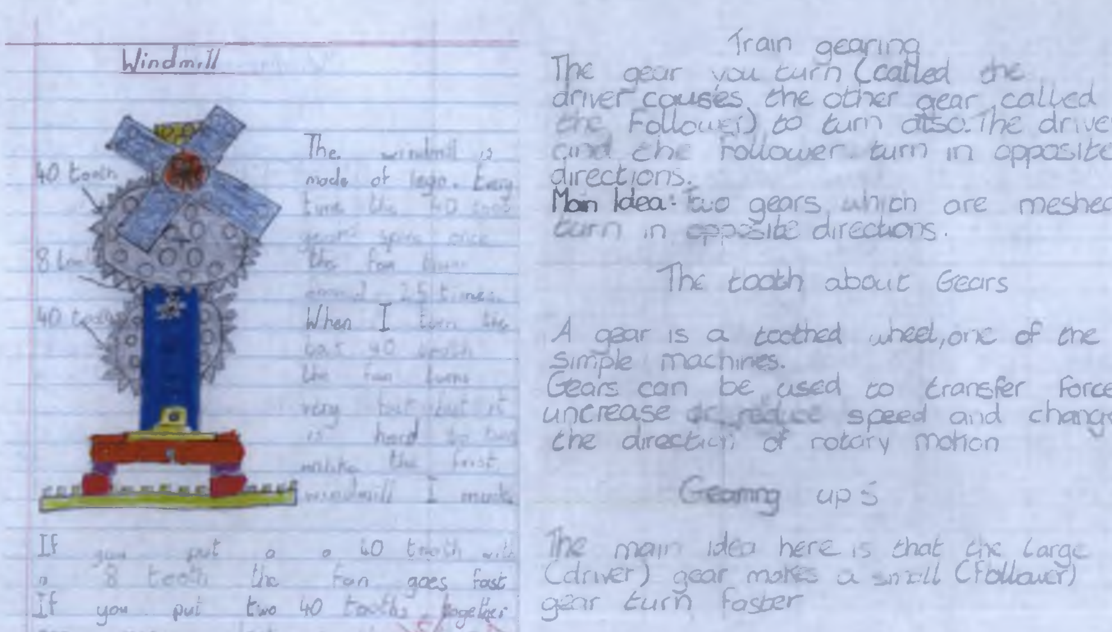
### *Building activities.*

From the outset, Richard totally controlled the children's building projects by planning a series of tasks they had to work through. First, he used the Yellow Kit teachers' booklets as a template for gearing; then he introduced pulleys, levers and wheels the same way. These booklets and component parts were intended only for teachers, to develop their own understandings of new concepts that they found so new and unfamiliar, but Richard used them as the framework for introducing the materials to his classroom and faithfully followed each activity outlined in the teacher guidelines.

So nothing had changed in Richard's classroom: he was still dictating every detail and not considering the children's needs or interests. He dominated the teacher-student relationship, keeping the interaction very much one-way and perpetuating the transmissive structure the children had become accustomed to in school.

"Stemming from [his] own insecurity, [he] thought it was necessary for the children to gain certain building skills before they could progress to creative building projects". (Richard's Master's Dissertation, June 2003, p.57). Their first task was to build a windmill in order to learn about gearing. Richard did this "in the traditional didactic method of having everyone build the same model from the plans and then record the work in a project diary" (Richard's Master's Dissertation, June 2003, p.55). (See Figure 43, below.) He also required them to use "the correct terms and vocabulary written on the blackboard to express the movement and ratio of the gears" (Richard's Master's Dissertation, June 2003, p.56)—an activity typical of Richard's traditional classroom approach as "curricular activities rely heavily on textbooks and workbooks" (Brooks and Brooks, 1993, p. 17).

*Figure 43:* Children's Prescribed Gearing Descriptions




Displaying his continued over-reliance on text-based activity, Richard felt he needed the children to write these formal and quite technical accounts about their building activity (See Figure 43 above) in order to be "satisfied they had a good understanding of what gears could do" (Richard's Master's Dissertation, June 2003, p.57). Children who had difficulty expressing their understandings and ideas in a written form, but who may have understood the gearing concepts quite clearly, found this requirement especially frustrating.

In contrast to the Vygotskian principle (1978), which holds that changes in tools will bring about changes in thinking, and that these changes in turn are associated with changes in culture, Richard had adopted the "fit" mentality in that he tried to "fit" these new computational materials into the traditional school structure and teacher's role.

### *Critical incidents.*

Richard tried to control every detail and action in his classroom, to the point of obsession. He was prompted by the "chaotic" memories of "hot glue gun" scenarios from his only other experience of project-based group work, which he constantly referred to with dread and loathing (Classroom visit, November 1999).

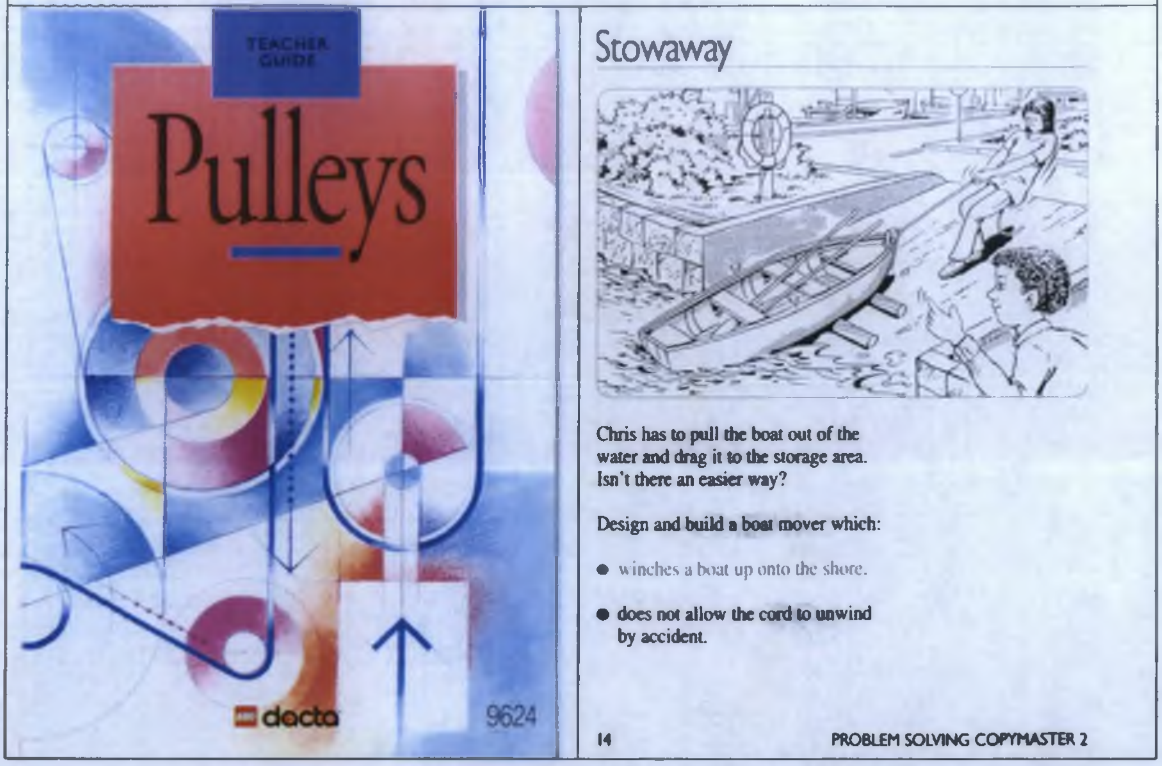
Richard's compulsion to control was all-consuming. His rationale: he wanted to prove to himself that something could be produced with these materials and that the children were actually gaining something from the experience that could be rooted in the existing curriculum. In spite of him, really, the children combined their creativity with the versatility of the materials to break through his tough armour of control, resulting in a number of "critical incidents" (Woods, 1993; Tripp, 1993). As Richard himself comments,

> During the years of my involvement in the EM Project, various experiences and classroom episodes changed my views of myself as a teacher. . . . It was through reflection on these events that I effected change in my pedagogy and methodology (Richard's Master's Dissertation, June 2003, p.39).

### *Children's Creativity Triumphs: Diversity of the Winch Devices*

Rather than selecting just sections of the text from the teacher's guidelines Richard was determined to follow the "text-book" (See Figure 44 below) in order to give the children a good grounding in the basic skills.

*Figure 44:* Design-a-Winch Task Specifications (LEGO Dacta Teacher's Manual)




Ironically this obsession with completing every suggested exercise lead to the development of a particularly significant event, which demonstrated to Richard the diversity possible with the materials and the ingenuity and creativity of the children. Faithfully following the teacher's book (see Figure 44, above) on how to use pulleys, Richard assigned his student to design a winch to pull a boat up a slipway.

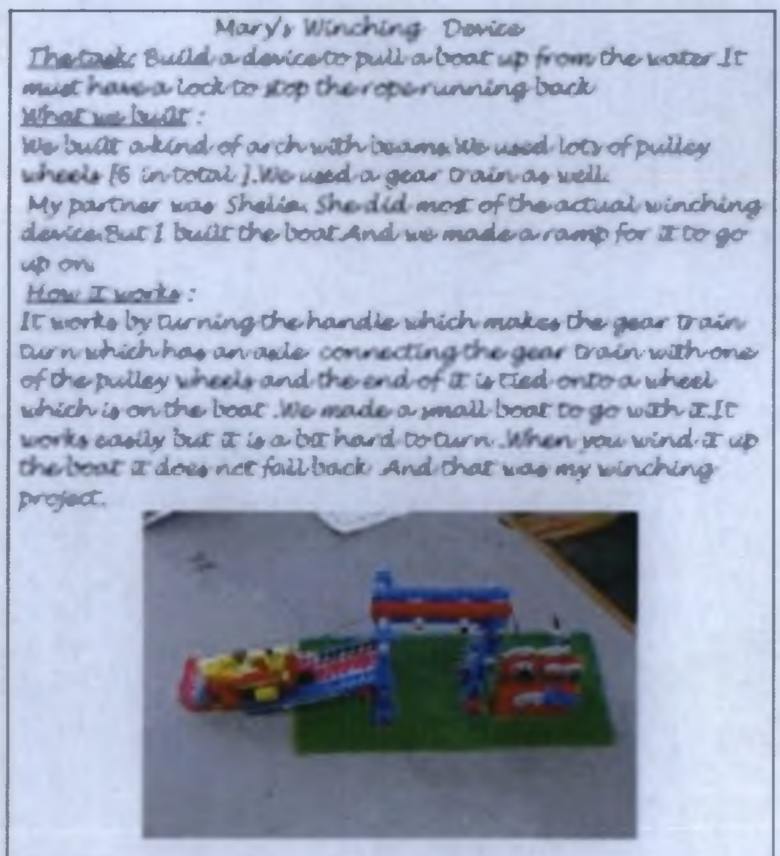
Richard assumed that the children's devices all would be similar, but much to his surprise, the children all designed very different winches. (See Figure 45, below.) When I visited his classroom at this time, he stated that he could not have begun to imagine the diversity and creativity the children had displayed in their constructions (Classroom visit, October 1999). Richard noted in his diary that "pupils worked in pairs and built very elaborate devices. . . . [C]oncepts learned earlier were employed and designs varied greatly" (Richard's diary, October, 1999). He was "very impressed with the creativity and richness of design . . . [and] began to realise the potential the materials had for creative and unique ways to address a given task" (Richard's Master's Dissertation, June 2003, p.59).

*Figure 45*: Children's Various Winch Constructions

After our discussion, Richard entered the embryonic stage of his reflective process of thinking about learning, which highlighted the significance of classroom visits to the EM supportive structure—it started Richard interrogating his classroom practice, using it as an object to think about learning.

### ***Tradition Wins Out: One Step Forward, Two Steps Back***

*Figure 46:* Sample Report of Winch Construction



Mary's Winching Device

The task: Build a device to pull a boat up from the water It must have a lock to stop the rope running back

What we built :

We built a kind of arch with beams We used lots of pulley wheels [6 in total ].We used a gear train as well.

My partner was Shelia. She did most of the actual winching device.But I built the boat And we made a ramp for it to go up on.

How it works :

It works by turning the handle which makes the gear train turn which has an axle connecting the gear train with one of the pulley wheels and the end of it is tied onto a wheel which is on the boat .We made a small boat to go with it.It works easily but it is a bit hard to turn .When you wind it up the boat it does not fall back And that was my winching project.

Although Richard was beginning to realise that there was more than one way to tackle a prescribed task, and he was impressed by his students' ingenuity, he still insisted that they write up reports of their tasks. And he gave them no freedom, but plenty of specifications (See Figure 46 above):

Richard still was not convinced that building alone is sufficient or a legitimate learning process. Although his students could take digital photographs of their models and describe how their construction, and the problems they encountered and solved collaboratively, Richard still was not satisfied. He continued to emphasize writing, constantly reinforcing his own belief that although other materials may be used, the *de facto* way to demonstrate intellectual accomplishment is to write about it.

### *The Bridge to Communication*

In October 1999, a new student joined Richard's class. This boy had just endured a traumatic flight from war-torn Bosnia; he spoke no English whatsoever, as his mother explained to Richard via an interpreter. With no English, this boy could not participate in much of what Richard did with the children during the normal school day. But he was fascinated by the MindStorms materials, so Richard let him spend a lot of time constructing models initiated by his own interests. Richard also put this child "in charge of the organisation of the materials, and he would sort parts and tidy them as the other children learned Irish" (Richard's Master's Dissertation, June 2003, p.61).

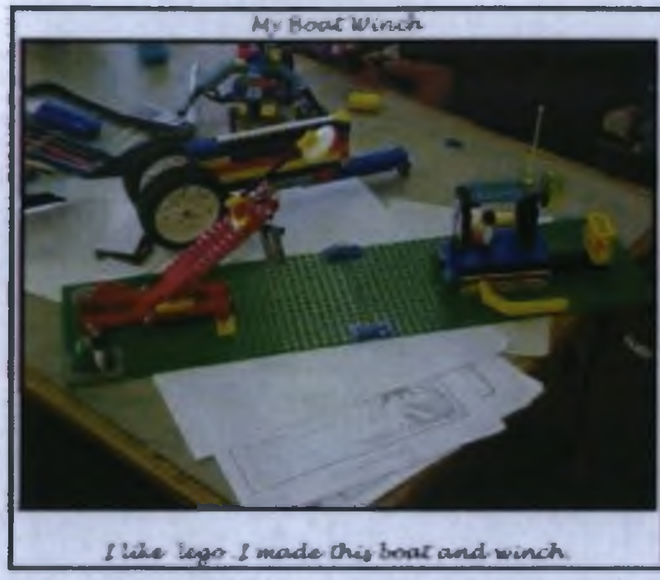
This traumatised child emerged as "a talented builder and organiser, and as the project progressed, his social interactions improved greatly" (Richard's Master's Dissertation, June 2003, p.61). Watching him interact with the other children in the class, Richard began to realise that it was possible to express meaning and have a common bond without sharing spoken language. He slowly understood what it means to use these computational materials and the artefacts they comprise as "an object to think with" (Papert, 1980).

Richard also realised that formal written text wasn't the only way to demonstrate conceptual understanding. This child could not speak English, let alone write an account of his activities, yet from the models he constructed, he was evidently developing a complex understanding of the principles of gearing, pulleys, levers, etc. Richard began to see the building activity as a vehicle for learning language in order to communicate with others about a shared activity (see Figure 47, below):

> [The Bosnian boy's] English skills also improved as he now had a context in which communication through English was important for him. He showed a willingness to write and . . . his first written work completed

after his first month in class was a picture together with a sentence about the winch he had built (Richard's Master's Dissertation, June 2003, p.62).

*Figure 47:* Bosnian Boy's First Written Work in English




Richard constantly describes his experiences with this child as one of the triggers that developed his understanding of the potential these materials have. He believes they "were a springboard for [his] integration and learning within a strange environment" (Richard's Master's Dissertation, June 2003, p.62). The materials were more than just a means of understanding formal concepts of gearing and how pulleys worked. They were a way to transcend language barriers and communication difficulties as well as a powerful way of developing a child's self-esteem.

This boy wasn't the only one of Richard's students who succeeded with the new computational materials; Richard noticed other children being uncharacteristically enthusiastic about classwork when it entailed using the computational materials:

> One boy with learning difficulties and a poor level of self-esteem and value has found a real outlet and talent for designing and building with these materials. He has demonstrated a new willingness in class, and his overall efforts in class are improving. I feel this is due to the project work giving him a new sense of his own talents and worth as an individual (Richard's diary, October, 2000).

He began to see these children's attitudes to school become more positive. Caught in a cycle of failure, they had few opportunities to experience "the feeling of being capable" (Humphreys, 1993, p.3), a central dimension to self-esteem, defined by Reasoner as "the degree to which people feel worthy, capable, significant and effective" (1992, p.12). Some parents even remarked to him that it was the first time their children had really enjoyed school. One set of parents were so delighted with their son's new self-esteem and positive attitude towards learning that "they purchased a LEGO Mindstorms kit for him so he could continue with his newly discovered talents" at home (Richard's Master's Dissertation, June 2003, p.68).

Parental expectations were changing; they were moving beyond textbook content because their children were thrilled by their creations and insisted that parents visit the school to see what they had been working on—a far cry from the norm, when parents usually arrived at the school only when they were sent for by teachers, or when parents themselves had issues with the school. Parents also loved exhibitions of student work because they could see for themselves their children's infectious, enthusiastic engagement in projects they could confidently and articulately describe upon request.

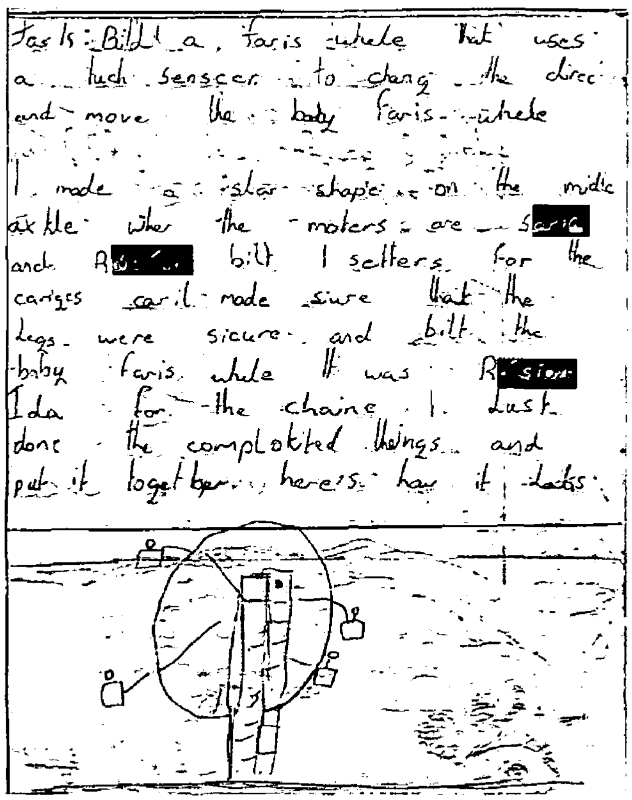
### *Expressing Meaning: Having an Object to Think With*

At the Young Scientist and Technologist Exhibition (January 2000), when the children were explaining to the public how they had built and programmed their models, Richard noticed that some children were much better at communicating orally about their work than they were at writing about it. He realised that he "had placed higher value on the written word, but listening to some children forced me to consider why this should be so" (Richard's Master's Dissertation, June 2003, p.66). So he decided to video some children explaining how they built their models. One particular 11-year-old stands out in Richard's memory as he confidently and articulately explains with enthusiasm to the camera how "his group used chains to construct the ride, gears to slow it down and pulleys to drive another revolving ride" (Richard's Master's Dissertation, June 2003, p.66).

A glance at the boy's written account of the project (see Figure 48, below) demonstrates clearly that the video was a more appropriate medium for this boy "to express himself and display his considerable talent for building and problem-solving, which to this point was not being recognised in his school life" (Richard's Master's Dissertation, June 2003, p.67). This boy's work in particular

> further influenced my view of the significance of these materials for new learning as I realised [he] could have left primary school without his building and problem-solving talents ever being discovered. This would have been a failure on my part, and it has serious implications for how I now regard children with learning difficulties in my class. (Richard's Master's Dissertation, June 2003, p.68).

*Figure 48:* Child's Written Account of Ferris Wheel Construction




Richard had other prompts to interrogate his beliefs and institutional patterns of practice (Warren-Little, 1993, p.139) that led him to question the traditional labelling of children as "bright" or "smart" and to reflect on "what underlying epistemologies are explicit or implicit in the policies and practices that are pursued" in the classroom (Sugrue et al., 2001, p. 13). He became aware of and began to question critically the "meaning perspective" (Cranton, 1996) upon which he based the construction of the learning environment within his classroom. He realised that his experiences of using these computational materials and the support within the EM community (Showers & Joyce, 1996; Darling-Hammond, 1996; Caccia, 1996; Raywid, 1993; Ruiz et al., 1995), particularly when coupled with opportunities for reflective thinking (Darling-Hammond, 1996; Hamilton & Richardson, 1995), had enabled him to develop his meaning perspective so that the learning environment within his classroom would foster learning for *all* learners. He realised that he had been guilty of an "over-reliance on writing as a form of evaluation of a child's learning" and that he "must place greater value on other forms of expression and not just the written word" (Richard's Master's Dissertation, June 2003, p.68). Working with the computational materials, these children whom he had previously considered as "less academic" and by association "not as bright or smart" (Conversation, December 1999) were now "able to engage in a different way":

> Rather than having to sit and assimilate information, . . . they . . . were able to explore and think for themselves and see that they too were as important as anybody else and that they had a valuable contribution to make. In fact, in some cases, they had even more value to give to a group because some of them were particularly good at the building. (Interview, June 2000)

Many believe that "because, in so many cases, teachers effectively teach themselves to teach, . . . they can teach themselves to teach otherwise" (Guskey & Huberman, 1995, p.217). But as Richard's dawning realisation demonstrates, he needed a combination of a supportive community and a period of time to allow for the development of ideas (Huberman, 1995), using classroom experiences as "an object to think with" (Papert, 1980) in order to embed his new learning "in the very routines of practice" (Sugrue et al., 2001, p.8).

### *Hard Problems: The Saga of the Black Line*

In spite of the diversity of building models he saw the children create, their persistent engagement with problems, the blossoming of their expressions of meaning, and the diverse learning styles working with the computational materials facilitated, Richard kept his stranglehold on all learning goal decisions. Insecure about his own abilities, he worried about losing face if he had no finished product to show at the end of the year, so he still did not allow the children any choice in their project, nor did he choose a theme to inform the building process:

> We had to decide what to do for this event, and I was reluctant to allow the children to make this decision, for I thought they would dream up ideas that would be impossible to build. I decided that we would build fairground models as we could always fall back on LEGO instruction sheets for building these models. (Richard's Master's Dissertation, June 2003, p.63)

As with the winch task, this seemingly innocuous decision to build fairground models ironically came to present a profound "challenge to my perception of my role as a teacher" (Richard's Master's Dissertation, June 2003, p.63).

Richard embarked on what he thought was a relatively manageable task to program a light sensor to follow a black line. However, he soon found himself with problem that seemed insurmountable, a problem that challenged his most fundamental assumptions about his work in the world. The "ghost train" (see Figure 49, below)

> was to follow a black line that meandered around like the track of the ghost train ride. The model used one light sensor, and this was to be

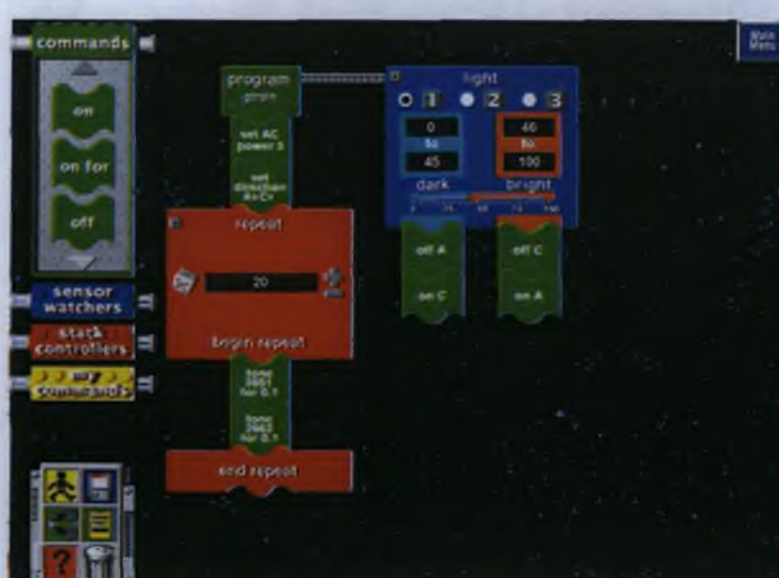
programmed to turn motor C on and motor A off for a black light reading, and motor C off and motor A on for a white light reading. This would ensure that the model followed the black line with a zigzag type motion.

*Figure 49:* Black Line Following Model

Looking at the program as written by the children, [see Figure 50, below] there did not seem to be any error in it. Yet when it was run the model failed to follow the black line. Despite numerous changes to the program and attempts to incorporate a second light sensor, the problem persisted. (Master's coursework assignment, November 2002, p.12)

The Black Line Problem became the focus of everyone's attention for quite a number of weeks, occupying every waking hour: "The Black Line! . . . It was on my mind, going to sleep at night: 'What is *wrong* with this bloody thing?! The program seems to be correct, the model's built, but why won't it *do it*?'" (Interview, June 2000).

*Figure 50:* Line Following Programme Written Using RCX Code




Having exhausted all possibilities and deeply frustrated, Richard asked the other teachers in the EM project group for help. Convinced it was a programming error, he asked them so send him suggestions or programmes that had worked with a light sensor, but all their suggestions were in vain.

After three weeks' struggle, the problem turned out to have nothing to do with the programming. Richard wrote two quite different accounts of the problem and its solution, at different times. His earliest description:

> *It was decided* that the problem must lie with the model's construction and not the program. The solution was in the end a simple one. The light sensor needed to be ahead of the driving wheels (Master's coursework assignment May 2002, p.13; my emphasis).

Note his use of passive voice and the complete absence of human agency from his description, as if Richard could not bring himself to admit that he did not have the answer ready to hand, so he had somehow fallen down in his duty as a teacher.

> This was a challenge to my perception of my role as a teacher as I believed I had to be always in control of the learning and always a step ahead of the children (Richard's Master's Dissertation, June 2003, p.65).

Later, though, after four years of support in reflective discussions (Darling-Hammond, 1996; Hamilton & Richardson, 1995) and the experience of working with his class in an open, Constructionist manner, he was able to tell the truth, accepting that not having the solution and being a co-learner with the children was a valid way of working as a teacher:

> *One boy decided* that the problem might be with the model's construction and not the program. *He* positioned the light sensor ahead of the driving wheels. Once it was repositioned, the program was perfect for controlling the model's movement. (Richard's Master's Dissertation, June 2003, p.64; my emphases).

Note the new appearance of human beings in Richard's story: *"one boy decided"*—and not even "with my help." The boy thought; the boy acted; the teacher took note and gave credit. Humbled and enlightened by new experiences, Richard was able to acknowledge that having all the answers, all the time, wasn't the only valid way for him to practice his profession:

> And then there was a particular sense of achievement when it was cracked . . . and to see the thing go off and do what you had really wanted it to do. . . .The first time it went . . . and actually did what it was meant to do, and the problem was solved, there was a collective cheer (Interview, June 2000).

This collaborative learning was in stark contrast to the norm in Richard's traditional-style classroom, where prior to the introduction of computational material, isolationist learning was the norm:

> We always expect everyone to work on their own ...and to acquire skills on their own. Whereas this gave a new idea. ... You were acquiring things together with other people and you were sharing your knowledge with other people...So, this was a new perspective on learning, ...we could, now look at problems as a group problem to be solved by a group and we could all work and assist each other (Interview with Richard, June 2000).

Richard was taken aback by the children's' persistence to engage with the Black Line Problem, as the norm during class was to give up on a problem rather quickly:

> The children really wanted to solve this problem because they wanted their Ghost Train to work. It was a concrete problem that they could see and make changes to easily. In addition, they were working with materials that they found more attractive (Conversation, May 1999).

Richard was beginning to acknowledge that by providing a means for the children to externalise their thinking and succeed in sophisticated problem-solving, the computational materials facilitated learning that was not possible before in his classroom:

> The problems that they would normally have to solve would generally be . . . focused on an academic solution to some question, which really has very little bearing on reality. We don't often present them with structures where there could be many possible solutions rather than one set solution (Interview, June 2000).

Richard believes the Black Line Problem was

> an important milestone for everyone because that then meant that's OK, there can be some problems that seem to be insurmountable, but they can last weeks, and the solution mightn't come. But when it does come, it's all the more rewarding (Interview, June 2000).

Richard saw his own learning very closely linked with the children's as they pursued their own needs and interests. He identified with their difficulties and developed a respect for their ingenuity, creativity and the deep learning they engaged in with a persistence he had never seen before in his classroom:

> I wasn't *teaching* them anything. It was self-discovery in many ways. And for me too it was a voyage of discovery because their problems became my problems and I worked with groups in trying to help them and solve them (Interview, June 2000).

Never before had he seen his students so interested in school; they were newly and truly invested in their own learning for the first time:

> They had ideas, they wanted to put something together to do something, and the problems presented themselves to the child. Therefore, the focus wasn't what I gave them to solve but here was something in life that they had to solve for themselves because the need arose and because that need arose for them, it was a personal problem or a group problem, and they all had to contribute to it and try to come to a solution together on it. . . . So it was internalised by them (Interview, June 2000).

Richard was beginning to realise that ownership is extremely important for engagement with the problem-solving process and closely linked to persistence.

### *The End-of-Year Event*

What we value as knowledge, shapes our understandings of what learning is and effects how learning environments are structured. In common with the Empiricist and rationalist traditions Richard viewed knowledge as an object. This is in stark contrast to the situated theories of learning that see an intimate connection between knowledge and activity or the 'social construction of knowledge' view which shifts us from a view of knowledge as an object to something that is not just a process but also a participatory construction process.

From the outset, Richard was product-focused. He introduced the materials to the children in tightly-focused, task-driven, tightly-timetabled sessions that left no margin for input by the children. Even though he had been impressed by their creativity with the boat winches, he still was determined that the classroom work with the materials would be "time spent learning something definite and not just fooling around and playing with LEGO" (Observation, Summer Workshop, 1999). He "continued with skills based activities to teach the children about steering, levers and pulleys, employing the same methodology as [he] had for the gearing exercises" (Richard's Master's Dissertation, June 2003, p.58). So in the building sessions, all the children worked on set tasks with the expectation of producing a predetermined product, which they then had to write up. The entire process was teacher directed and content focused with no account being taken of the children's individual needs and interests.

Richard's decision to get the children to make fairground models for the end of year event was influenced by the fact that the original supply of the computational materials had come from the LEGO suppliers packaged in Amusement Park sets. Although everyone at the teachers' workshop agreed that the Story, Myth or Legend theme should inform the development of this project based learning process, Richard did not consider this but concentrated on developing models that would incorporate the skills he had spent time developing with the children. When the children had completed the Yellow Kits, they began working on building models for a fairground or amusement park, with the kits to fall back on if necessary. Some children followed the building plans that had come with the kits (e.g., Bumper Cars, Ghost Train) while others worked on designing their own variations of these models and other fairground attractions. Choosing this approach meant that if all else failed Richard had the building plans, which came with the kits to fall back on if the children could not make working models of their own design.

By working "in an Instructionist way, telling the children what I wanted them to build but allowing them some freedom to make their own designs" (Richard's Master's Dissertation, June 2003, p.65), Richard created an environment in which he felt safe and in control. To save face with the rest of the EM group and to be able to say that the project reflected a story theme as had been agreed, "once we had the fairground models built I had the children search the school library for a suitable book, and we found one called *The Haunted Carousel,* by Carolyn Keene" (Richard's Master's Dissertation, June 2003, p.65). Satisfied that he now had some models and a theme that fitted Story, Myth, and Legend, Richard concentrated on "getting everything working for the exhibition" (Conversation, March, 2000).

### *The richness of context.*

Possibly because it was such a large, high-profile occasion, Richard had a very negative reaction to the first year-end event. He felt he had bee "on show, and that my personal inadequacies were on display" (Richard's Master's Dissertation, June 2003, p.70). Also, he "was struck by the diversity of the work from the other classes and felt intimidated by how many classes had used artistic materials in conjunction with the LEGO models" (Richard's Master's Dissertation, June 2003, p.69). Commenting in retrospect, he says,

> The characterisation of people from story combined with the artistic displays was wonderful, but my feeling was that my class display lacked these features and that I as a teacher could never aspire to such creation. . . . I was feeling that the work I had done was inferior to that of my colleagues, and I didn't think I had the artistic skills to produce such creations. (Richard's Master's Dissertation, June 2003, p.70; my emphasis)

By focusing exclusively on product, Richard had effaced the very thing that gave these other models life: their genesis in a story context. In trying to capture this story, the other teachers and their children had used a variety of different means and materials. For example, the children telling the story of the Devil's visit to Castletown House faithfully recreated the dining room where the event occurred. All the models interacted in this handmade, wooden stage set as the story unfolded. To the children, the models meant nothing without the concrete framework for their story. This wooden structure tied their construction activities to their visit to Castletown house where they had first heard the story. These children had a story they wanted to tell and did not see each of their models as a separate entity. They had chosen the theme and the construction of this story had involved many activities that were not exclusively centred on just using the computational materials (See Martin et al., 2000, for descriptions of other thematic projects developed in EM classrooms).

Richard and his children, on the other hand, had been focused on building a discrete product that was not situated within a context that had informed the construction process. The product itself became the focus, rather than creating a context within which the model/artefact recreated meaning for the children.

### *Dual Existence*

Even at the following year's summer EM workshop (August 2000), Richard made it clear that he still viewed the time spent working with the materials as entirely distinct from regular curriculum work, and there was to be no overlap or crossover.

His Jekyll-and-Hyde approach emerged during one of the breakout sessions from building, when the teachers new to the EM project asked the first group of teachers how they managed the project. Richard very confidently described in great detail how he previously had relied exclusively on whole-class teaching, but now he was organising the children into groups to work with these computational materials. He continued with great eloquence to outline how he restructured the classroom to facilitate the group work and outlined the plan of work he had followed during the year. He talked passionately and sincerely about the models the children built and their tenacity in problem-solving.

As an example, he outlined the long, frustrating struggle to solve the Black Line Problem. The new teachers were all very impressed. One of them remarked that what he had outlined was very revolutionary, and wondered if these experiences had had an impact on how he organised the rest of his work with the class. To everyone's bemusement, he quickly retorted—as if shocked by the assumption that his practice should have changed for any other part of the school day—"Oh, no! No, not at all. Once the building sessions are over, everything returns to normal. The furniture is put back in rows and the materials are all locked away in the cupboard until the next building session" (Summer workshop fieldnotes, August 2000).

His response is especially paradoxical because he did seem to realise the possible potential of the materials for new ways of expressing meaning and for sustained engagement with problems.

> To see the way they could engage in it in fact was quite an eye opener for me as a teacher, how children could engage in trying to solve difficulties. I didn't often experience children giving up on the problem. Most of them would stick at it until a solution came (Interview with Richard, p. 7, June 1999).

And he had also witnessed how the materials had been a means of social integration and motivation for communication.

Somehow, though, Richard did not seem to have a problem with these two very different learning environments coexisting in his classroom. Perhaps by returning the classroom to its traditional organisation of rows, he met his deeply-rooted need to control when he confined the materials "within the box" (literally: recall the separate storage press he purpose-ordered). By being so rigid and ring fencing the computational materials sessions prevented any cross-contamination as it were. He could deploy the materials *and* continue his traditional Instructionist practice, so comfortable after 28 years. He did not have to change, and think "out of the box," or begin to face the challenges and questions these new learning experiences were bringing to the fore.

Richard continued to work with these materials with successive groups of children over the next three years (2000-2003). It was customary, in his school, for teachers to work with different groups of children from year to year. Starting out with a new group of children each year may have helped Richard build up some confidence and encouraged him to take the risk of loosening his grip. Once he had ironed out what to him were important organisational factors—sorting, classifying and storing the materials, timetabling the building sessions, planning a work schedule and grouping the children—he was less fearful about working with the materials.

The summer workshop (August 2000) also helped him develop his construction and programming abilities. He "found this work very valuable in giving me greater confidence to help children with problems they might encounter" (Richard's Master's Dissertation, June 2003, p.72). And the discussions with the new teachers helped him understand just how far he had developed in coming to grips with the computational materials. But he "still held set ideas on what constituted good organisation and [a] desire that . . . the new teachers should follow a pattern similar to my own way of working and managing the project in their classrooms" (Richard's Master's Dissertation, June 2003, p.71).

Prior to the workshop, when asked about what would be beneficial for the new teachers in the project, he believed there were

> problems of organisation that would need to be looked at with people . . . how they're going to work the project in the classroom, how they want to timetable it in, how materials are stored, all those issues were issues for *us* at the beginning. . . . They were *big, big* issues, and it took a while to sort them out. (Interview, June 2000).

Notice how he classifies the organisational issues as being of utmost importance with the use of the word "big," which he repeats for special emphasis. He also projects his own personal, overarching concern with organisational issues collectively onto everyone in the group when he uses the word "us."

### *Loosening His iron Grip*

When he saw the broad and imaginative interpretations of the story theme by the other teachers and children at the end-of-year event, Richard was a little more convinced that working in a thematic way was possible. The "meaning perspective" (Cranton, 1996) that informed the construction of the learning environment within his classroom had been shaken, and he was unsure about his own ability to realise such a thematic project. However "meaningful intellectual, social and emotional engagement with ideas, with materials, and with colleagues both in and out of teaching" (Warren-Little, 1993, p.138) gave him courage:

> The discussion sessions were stimulating as teachers expressed a variety of views about how they worked and what they might do in the next year and I was satisfied with the theme of Story, Myth and Legend as a basis for the class work this time round (Richard's Master's Dissertation, June 2003, p.72).

But Richard wasn't ready for a complete turnabout in his approach to working with the computational materials in the subsequent school year (2000-2001). He still believed strongly that the children needed prerequisite skills first before they could begin to construct models of their own design. Again, he

> began the class work as I had done the previous year by having children follow the same lessons on gearing, pulleys and levers. . . . The only real change was that I decided we would use a novel as a theme for the project as I was keen to follow the group theme of Story, Myth and Legend (Richard's Master's Dissertation, June 2003, p.72).

After his class completed their "pre-requisite" activities with the Yellow Kits, he

> introduced . . . the RCX and motors. They learned to program simple vehicles to move forward and reverse, and emit sounds. Then, they explored how to program the vehicle to turn. Following this, they employed touch sensors to make their models reverse or turn. Finally, they added light sensors and programmed them to react to light and dark readings (Richard's Project Report, June 2001, p.1-2).

### *Richard Introduces the Element of Choice*

Rather than leave the choice of the theme around which to centre the project up to the children, Richard restricted their selection to a very narrow list of three novels they had read in class—*Harry Potter and the Philosopher's Stone, Holes,* and *Willie Wonka and the Chocolate Factory.* Richard allowed the children vote for their theme. "The ballot was done using the PR system, as an election was under way nationally at the time. The quota was 17 and Willie Wonka was first to exceed the quota" (Richard's Project Report, June 2001, p.1). The selection was restrictive, by doing so, though, Richard had established the first tentative link among the computation materials, a curriculum area (English literature), and the children's everyday social reality (the government's contemporaneous General Election).

And "unlike the previous year, we discussed what models could be built based on this story" (Richard's Master's Dissertation, June 2003, p.72). Practising uncharacteristic restraint, Richard decided not to dampen their enthusiasm and allowed them to pursue their interests and the goals they had set themselves. Filled with enthusiasm, the children had countless project suggestions, and finally settled on building:

> Willie Wonka, a gobstopper machine, a sweet loader, a glass elevator, the wall and gate of the sweet factory, an Oompa Loompa, a Wonka train, a

> conveyor belt, a sweet making machine, and a good egg -bad egg separator." (Richard's Master's Dissertation, June 2003, p.72)

Richard noted in his diary that "some ideas are very ambitious and it will be interesting to see how the groups approach their ideas" (Richard's Diary, February, 2001).

Perhaps encouraged by the children's rapturous excitement and undaunted optimism, and buoyed up by the accomplishments of his previous class, Richard made a leap of faith to believe in and trust the children. But while he relaxed control with regard to the groupings and the models to be built, Richard did not let go of the reins entirely. He still timetabled building sessions, and after each session,

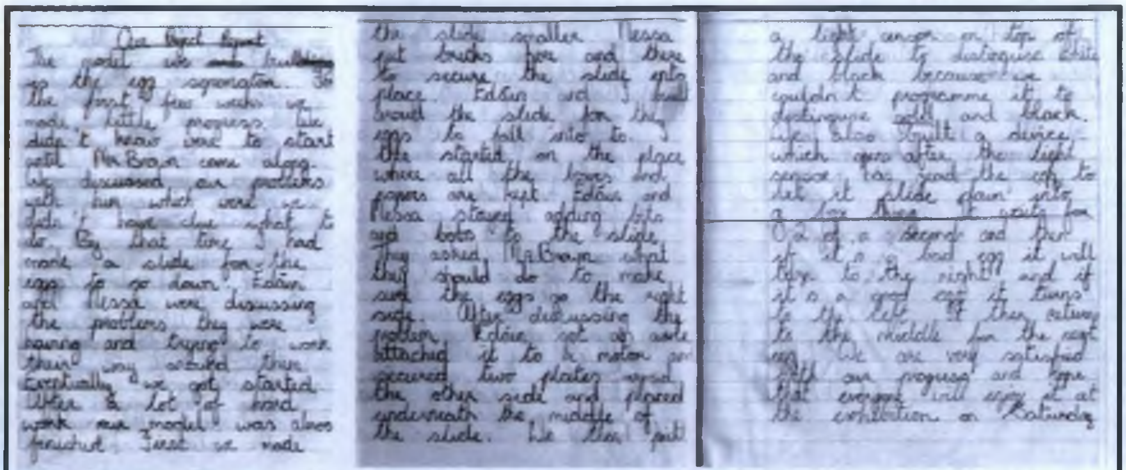
> Work was stored in a lockable press and for building sessions tables in the room were reorganised. Each group of children had to appoint a "gopher" to fetch required parts. This was necessary to cut down on movement of children throughout the room (Richard's Project Report, June 2001, pp.5-6).

### *New Relationships Develop*

In the following weeks, Richard and the children encountered many difficulties and "a new type of relationship developed" between them because "now we had to work together to find solutions and I was as involved as they were with the problems" (Richard's Master's Dissertation, June 2003, p.74). During my visits to his classroom, I noticed that he still rearranged his classroom for group work with the computational materials, and he locked everything away at the end of each session. However, he was noticeably more relaxed and more confident about letting the children take the lead (Observations during classroom visits, Jan. – Mar. 2001). Because he had realised and accepted the fact that he neither had, nor was he expected to have, all the answers to their construction and programming problems, he was able to take a more facilitative and interrogative approach with the children. The children themselves noticed this change in the working relationship:

> Édáin and Nessa were discussing the problems they were having and trying to work their way around them. Eventually, . . . they asked [Richard] what they should do to make sure the eggs would go down the right side. After discussing the problem Édáin got an axel [sic *passim*] attached it to a motor and secured two plates around the other side and placed it underneath the middle of the slide (Diary entry from Egg Separator group, See Figure 51 below).

*Figure 51:* Sample Report from Egg Separator Group



Our Project Report

The model we [illegible] building is the egg separator. In the first few weeks we made little progress. We didn't know where to start until Mr Brown came along. We discussed our problems with him which were we didn't have clue what to do. By that time I had made a slide for the eggs to go down. Edwin and Nessa were discussing the problems they were having and trying to work their way around them. Eventually we got started. After a lot of hard work our model was almost finished. First we made the slide smaller. Nessa put bricks here and there to secure the slide onto place. Edwin and I built around the slide for the eggs to fall into. I [illegible] started on the place where all the boxes and papers are kept. Edwin and Nessa stayed adding bits and bobs to the slide. They asked Mr Brown what they should do to make sure the eggs go the right side. After discussing the problem Edwin got an axle attached it to a motor and secured two plates around the other side and placed underneath the middle of the slide. We then put a light sensor on top of the slide to distinguise white and black because we couldn't programme it to distinguise gold and black. We also built a device which goes after the light sensor has read the egg to let it slide down into a [illegible]. It waits for 0.2 of a second and then if it is a bad egg it will turn to the right and if it is a good egg it turns to the left. It then returns to the middle for the next egg. We are very satisfied with our progress and hope that everyone will enjoy it at the exhibition on Saturday.

Child's account of the Egg Separator model as part of the Willie Wonka Project Theme

Richard stopped insisting they adhere to a strict formula when writing their project reports, so those documents began to take on the characters of their authors (See Figures 52 and 53, below).

*Figure 52:* Sample Report from Willie Wonka Group

**Willy Wonka**

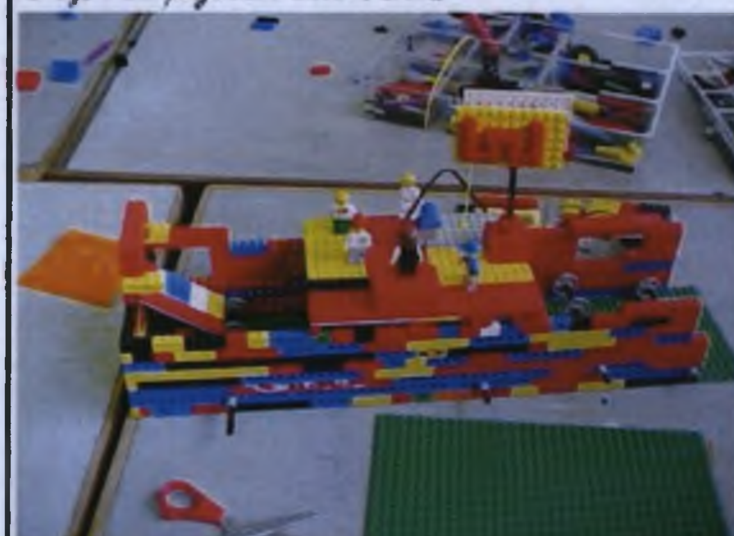
We are building a lego model of Willy Wonka. His eyes light up. His right arm moves up and down. He is wearing a red jacket. We had a problem with keeping his head on his neck. We had another problem, most of his body parts kept falling off. So we made his neck a bit bigger and the body parts stronger. We programmed the RCX to make his arm move up and down. We also programmed his eyes to flash on and off.

Now that they were not constricted by a particular writing formula or particular medium in which to express their ideas, the children not only used pen and paper to record their progress, but they also made use of the digital camera and the word processor. Consequently, the children were more inclined to write about the difficulties they experienced and how they overcame them, or modified their ideas.

*Figure 53:* Sample Report from Sweet-Making Machine Group

The Sweet Making Machine

Our group had to build a sweet making machine. We started off with connecting a sort of conveyor belt like feature to the RCX. When the RCX is switched on, the feature moves. The idea is to be able to move a small base plate along it. Fortunately, we had no problems with the model. Our machine has two conveyor belts attatched, so the whole idea is to put a plate with small bricks on that when it reaches the end of the first belt, it falls off, and the other belt starts up with big bricks on it. Now, it looks as if the small bricks went in, and came out big. It also plays music while in action.



None of the significance here was lost on Richard:

> This working alongside my pupils engaging with the same problems was a new role for me in the classroom, and it made me reflect on my teaching style heretofore. I was beginning to understand that this new way of learning and engagement in sustained problem solving had something to teach not just my pupils but also me as a teacher (Richard's Master's Dissertation, June 2003, p.75).

### *Visible Learning*

With these computational materials, Richard and his students designed and constructed "external artefacts" that made their learning process visible for all to see and think about—and with. For Richard, their learning was particularly obvious at the parents' evening in his school, and the year-end exhibition of all the school's projects.

The models his students had built were the concrete embodiment of the knowledge they had constructed for themselves. The children confidently explained and discussed their models, and they were not at all upset if something quit working or had to be adapted. Richard was able to understand that the children not only understood the principles behind their constructions (e.g., gearing ratios, torque, friction) but also could verbalise their thinking and articulate their learning processes.

### *New Lights Shining*

As Richard grew into his new role as co-learner with his students, he saw the same blossoming of particular children as the year before. The benefits of the project work for the children considered as academically weaker were reinforced:

> In particular the less academically achieving children were much happier in school and were very capable in using the LEGO materials. This sense of achievement was usually absent from their experiences in school . . . Weaker children showed increased motivation and higher self-esteem (Richard's Project Report, June 2001, p.5).

In his diary, Richard notes how one boy's engagement with the computational materials was in marked contrast to his other schoolwork:

> One boy with learning difficulties and a poor level of self-esteem and value has found a real outlet and talent for designing and building with these materials. He has demonstrated a new willingness in class and his overall efforts in class are improving (Richard's diary, October, 2000).

These observations were affirmed for Richard by some of these children's parents later in the year at a parent-teacher meeting:

> In particular the parents of [one boy] had high praise indeed for the work being done, saying that this was the first year they had no tears about going to school . . . due to his fears of failure and underachievement. With the project, he now feels he is able to achieve and is finding school rewarding. (Richard's diary, January, 2001)

Richard was courageous in slackening his control and engaging more with the children as they worked collaboratively within a narrative theme. And he received further affirmation through his observations "of the children's successes, their ability to work collaboratively at problem solving, their increased motivation and the joy and pride exhibited in their work" (Richard's Master's Dissertation, June 2003, p.76).

The children had also "engaged in a more creative way with the materials and had integrated the project theme into their writings, art, music, and literature studies"

(Richard's Master's Dissertation, June 2003, p.76). This "cross-curricular and integrated work" dispelled "the nagging doubts I had experienced about covering curriculum content in the previous year" (Richard's Master's Dissertation, June 2003, p.76). The year-end exhibition (June 2001), rather than being negative or intimidating, was a positive experience for Richard and his "own self-esteem as a teacher was reinforced (Richard's Master's Dissertation, June 2003, p.77). So in his report at the end of his second year with the EM project (2000-2001), he was much more positive, aware that his experience using the computational materials within the supportive framework of the EM project was beginning to bear fruit in his teaching:

> I find I am still on a voyage of self-discovery in my teaching in this project. I find new problems, challenges and strengths emerging as I progress through this work and look forward to my next class and the challenges they will present me with. (Richard's Project Report, June 2001, p. 6)

He was still concerned with producing good "product" though, as he notes that the models for the end of year exhibition were "very complex" (Richard's Master's Dissertation, June 2003, p.77), but at least this was not his exclusive focus. He also knew the constructions captured the story well and in an artistic manner. He was "more convinced of the value of the Story, Myth and Legend theme" (Richard's Master's Dissertation, June 2003, p.77) but saw it "as a means of situating the EM Project into the curriculum" rather than pursuing the needs and interests of the children. Richard's original assumptions, however, were challenged sufficiently by his experiences within the EM project that despite a previous resolution never to engage with further studies,

> now I want to study and I have a desire to learn and look into what I have experienced in the project in more depth. And what other teachers are experiencing. Certainly it has brought on a desire in me to go back and look at study and think and reflect on what I am doing. In terms of my own in-service development it [the EM project] certainly has had a big impact on me (Interview, December 2002, p. 13).

Richard went on to pursue a Master's degree (2001-2003). The focus of his dissertation was "how the EM Project influenced my educational thinking and inspired me to make significant changes in my teaching methodology" (Richard's Master's dissertation, June 2003, p.35).

### *The Watershed*

Richard's third year with the EM project was the watershed in his development. If classroom work were to be taken as sole indicator of his development, one would think he actually had regressed because he did not develop an elaborate story theme as in Year Two, but worked instead on a series of focused tasks. As his Master's coursework makes abundantly clear, however, he devoted his energies to reading and reflection in order to understand events in his classroom as a result of his engagement with the EM project. In effect, Year Three was his time out for reflection, to understand and reconceptualise his own assumptions about teaching and learning that had been seriously challenged by his involvement with the EM project. Indeed, even in his thesis, when he analyses his development as a teacher within the EM project, he hardly mentions his third year (2001-2002). He states, "I found I was too busy with assignments and two elective pre-service students who came to work in my class. For various reasons I found the year was more disruptive than previous years" (Richard's Master's Dissertation, June 2003, p.77).

His watershed year started very differently. As the new class had worked with the materials the previous year, Richard "didn't see any need for structured lessons to teach about building concepts, and the class immediately commenced working on a fairground theme" (Richard's Master's Dissertation, June 2003, p.77). Throughout the year, the children built models of fairground rides, moving targets, an incline climber, bugs, and the fast vehicle challenge. The children chose all of these themes except the last and, for big blocks of time, Richard actually relinquished control of his class to two preservice students, thereby devolving considerable control and letting observe the learning processes of the various groups and individuals within his class. He was not yet quite able to let the children entirely control their own learning, but he designed a learning environment he did not ultimately control and by doing so, he gave himself the space to reflect and try to connect what he saw in his own classroom with the writings of others. He was "stepping out," as Ackermann describes, from the immediacy of the classroom experience:

> I believe that both "diving in" and "stepping out" are equally important in . . . understanding. I argue that separateness resulting from momentary withdrawal does not necessarily entail disengagement. It may well constitute a step toward relating even more closely to people and things. . . . (Ackermann, 1996, p.28)

Serendipitously, Richard had a family commitment on the day of the year-end project exhibition, so without the pressure of his own need to show a "good product," he was "quite happy to let the children conclude their work with the student teacher" (Richard's Master's Dissertation, June 2003, p.78).

On the down side, however, even though these children had a year's precious experience working with the computational materials, Richard saw the story-based theme as informing only the work for the year-end event, not as a means of structuring the work done during the remainder of the school year. So his students had no opportunity to develop deep projects informed by self-chosen, story-based themes, in stark contrast to the students whose entire work ripened out of a single narrative theme (Tommy—"Earthquake in Springfield," "The Break-In") or local events (John—David's and Derek's cranes inspired by neighbourhood regeneration).

And Richard still believed that the children had to develop particular skills before they could tackle the building of models based on a story theme. So although hi students did not use the step-by-step approach of the Yellow Kits, he still set them to work on specific tasks, all at the same time, to develop particular skills or concepts—e.g., "the incline climber"—for conceptual understanding of gearing down and torque. He handed over some control to the children: allowing the children to select their own partners or groups and solve the posed problem in whatever way they saw fit, but Richard was still in the driving seat, setting the learning goals.

His Master's programme at St. Patrick's College spanned his third and fourth EM. He focused these two years (with me as his director) on understanding the philosophy behind the EM project and the ways teaching and learning in his own classroom changed and developed. Constructionist principles informed the course design, with ample time for reading and reflecting on classroom practice. Participants decided upon their own coursework and assignments, which they designed to meet their individual needs and interests.

### *Richard's Fears/Concerns: Parental Attitudes, and His Need for Approval*

During his first year of post-graduate work, Richard took a hard look at his need to control his students' learning process. He identified strongly with Brooks and Brooks' (1993) view that "many teachers are reluctant to allow pupils to be in charge of their own learning as they worry about losing control or being seen as less effective by parents or by the school authorities" (Richard's Master's Dissertation, June 2003, pp.77-78). Richard himself had been profoundly influenced by parental perceptions and expectation of him as a teacher:

> Many teachers would be reluctant to allow pupils to be in charge of their own learning as they would worry about losing control or been seen as less

> effective by parents or by the school authorities. It is perceived to be better to have quiet and orderly classrooms than have activities where children are engaged in sharing information and solving problems cooperatively as this makes for noisy classrooms (Masters' coursework assignment, January 2002, p.4).

Richard had many fears about what parents might think if he devoted too much time to working with the computational materials in his classroom:

> As I teach in a school with three streams, I was worried that I was not devoting adequate time to the defined curriculum, . . . [and] aware that my colleagues were advancing through textbooks and teaching lessons in subjects which I felt I was neglecting. I was worried that parents would notice this and possibly complain. I was unsure if I could argue cogently for what I was doing with these materials. I was also concerned about the learning that was taking place and if it could be documented if I was challenged to justify the time spent on the project (Masters' coursework assignment, November 2002, p.15).

### *"Totally Gobsmacked": Parents React*

Richard soon discovered that "as long as I gave adequate time to Irish, English and maths, parents did not mind other subjects receiving less attention than normal as they could see the benefits of the project work in their children's attitude and motivation for school" (Richard's project report, June 2001, p.5). As the year progressed, he realised that his "concerns were unfounded as parents were enthused by children coming home and telling of their work. Many parents requested visits to the classroom to view their children's models" (Masters' coursework assignment, November 2002, p.16).

And they never put him on the defensive. Contrary to his expectations,

> there were a lot of [parents] who were very keen to come in and see what was happening here. . . . Another thing the parents did too, in my class: quite a few of them bought the kit. . . . They had an opportunity to work, then, with their kids at it (Interview, June 2000).

He had not experienced this parental behaviour before with senior classes. These parents, though, were "fully supportive" of him using the computational materials with the children. In fact, he "didn't have anybody in the group whose parent felt that this was a waste of time. Everybody was right behind it" (Interview, June 2000). And it "was often pointed out that children who had a dislike of school were greatly stimulated by the project and parents had noted a general improvement in their children's schoolwork" (Masters' coursework assignment, January 2002, p.13). Indeed:

> At the annual parent/teacher meetings, the parents . . . reported that the children were very excited by the challenges and enjoyed talking about and displaying their creations. It was particularly rewarding for children who had poor self esteem and who felt they were seldom praised for their schoolwork in other subjects. (Masters' coursework assignment, November 2002, p.16)

Richard believes that the open-school events and the children's annual participation at the National Young Scientist and Technologist Exhibition also contributed to the parents' enthusiasm:

> Parents were totally gobsmacked—that's the only word to describe it—by . . . the work. . . . [A] lot of appreciative parents . . .thank[ed] me for the work that we had done on the project [and] . . . expressed the view that the children's' participation in the Young Scientists' exhibition was something that their children would never forget. It was a milestone for them; there was great excitement around the whole event. And generally their children had a very positive view of school and felt they'd had a great year at school (Interview, June 2000).

These events also encouraged him to continue using the computational materials and change the way he worked with the children.

### *Constructionist Ideas begin to blossom*

In his fourth year, in contrast to previous years, Richard helped define classroom tasks, but he did not prescribe the children's solution strategies. Instead, he stood back and observed different groups' approaches to problem-solving.

Richard could not have anticipated the learning goals his students pursued on their own. In one instance, all but one of the groups had attached the wheels directly to the motors in order to propel their vehicles (See Figure 54 below):

> This group . . . had built a vehicle with wheels and were trying to find a way to add a motor to it . . . [but became] very frustrated at not knowing how to bring motive power to the wheels. One of the group suggested gears as a possibility but did not know how to connect them to the wheels or the motors (Richard's Master's dissertation. 2003, p.79).

Observing closely, Richard decided to intervene as he felt they were close to a solution and was afraid that their lack of building knowledge would prevent them from discovering how to use gears and prevent them from completing the task. He showed them "what parts could be used to make gears mesh and stay in place." Motivated by their initial idea (to use gears) and Richard's gentle assistance, these children "worked cooperatively for some hours, and it took several attempts for them to reconstruct the model to incorporate gearing (See Figure 55 below).

*Figure 54:* Vehicles with Motors Attached Directly to Programmable Brick

But when it worked, the sense of satisfaction and achievement was almost overwhelming for the children" (Richard's Master's dissertation, 2003, p.80). Richard "did not actually provide them with an answer" but "encouraged their thinking to find their own solution" (Richard's Master's dissertation, 2003, p.80) (See Figure 55 below).

*Figure 55:* Gearing Incorporated to Construct a Moving Vehicle

His new approach was "in direct contrast to how children were taught by me about gearing through following my pre-designed building tasks in the previous years" (Richard's Master's dissertation. 2003, p.80). Although he had set the task, it was open-ended, the children worked in groups of their own choosing, and they were not required to follow specific steps or to use specified materials. Richard intervened only when the children were getting frustrated and were on the point of giving up. He did not supply them with a solution but followed their idea of using gears and gave them just enough assistance to enable them to continue working on their own idea.

Rather than limiting the building session to the usual one-hour slot, Richard also allowed extended time for these children to construct their model successfully by incorporating gearing: "The discovery of gearing by this group stimulated others to reconstruct their own models. . . This was like a viral spread of knowledge, and it spread from group to group and without my direct involvement" (Richard's Master's dissertation, 2003, p.81). Gracefully relinquishing his characteristic need to control, Richard watched in fascination as all the groups set about reconstructing their models to incorporate gearing. To his amazement, their learning was not only infectious but also self–perpetuating: "Through discussion and rebuilding, other groups discovered that in their gearing arrangement the model's speed was increased, and for others the effect was to slow the vehicle" (Richard's Master's dissertation, 2003, p.82).

Motivated by this new discovery of the consequences of "gearing-up" and "gearing-down," the children then set themselves the challenge of a series of races. They began designing vehicles that would travel very quickly or very slowly. Richard "was learning too"—he realised that, motivated by their own interest and given the freedom to control and manage their own learning, his students had "learned about gearing just as quickly as in previous years . . . [and] . . . understanding was reached in a more meaningful and personal way [with] less emphasis on product" (Richard's Master's dissertation. 2003, p.82).

Richard likens this series of events to an incident Papert describes when working with a group of children as they discovered the concept of friction: "So it is in the making of these cars—in the Constructionism—that we create the context about physics" (Papert, 1990, p.10; cited in Richard's Master's Coursework October 2002, p.1). Richard claims that Papert's example "resonates with my own experiences of what children have done in my classroom" (Richard's Master's Coursework October 2002, p.1). He believes that as a result of his own classroom experiences working with the computational materials, he has understood and personalised Papert's dictum about the importance of creating a context for a different way of learning. Richard states, "The word 'Constructionism' is the key here, for it goes beyond simply learning through doing but appropriating the knowledge by being driven by their own desire and sense of values" (Richard's Master's Coursework, October 2002, p.1).

However being convinced of underlying principles does not necessarily equal competence in translating these principles into practice (Bolhuis, 2000). Richard is torn between the role he has grown accustomed to for over twenty-five years as a teacher and the new aspects of his role that he wishes to develop. Although he states that he will "allow the children to take charge of their own learning", it is he who decides on the learning goals when they first begin working with the materials. In effect it is his needs and interests that are still to the fore and not the children's. Initially Richard sets them a task "to build a vehicle with motors attached" as he "wanted to see if children would discover how to bring power from motors to wheels and also incorporate the RCX brick into their model" (Richard's Master's dissertation. 2003, p.79). While acknowledging that this approach to introducing the materials to the children is radically different from previous years when they were confined to tightly bound restrictive objectives using instructions sheets and a limited set of materials, the children have not set their own learning agenda. Richard believes he is "*allowing* the children free exploration" (Richard's recorded diary 12/9/2002). However he does not realise that their 'exploration' is restrictive as it is bounded by the particular conditions that he has set. Even the language he uses illustrates that he unconsciously still sees himself in control. It is because he has *allowed* it that "they *have* to build this vehicle *so that they will discover* what the problems are and *will have to devise* their own solutions (italics added, Richard's diary 12/9/2002).

Ultimately, though, he stills sees himself as the most powerful element in the learning process. With the exception of the final narrative theme, Richard, not the children, set the tasks for the remainder of the school year. But these tasks were different from the previous years' in being more open-ended and set within a theme. Classroom organisation is also radically different and the locked cupboard, "a symbolic icon of the compartmentalisation of [his] teaching into blocks of subject based learning." (Richard's Master's Dissertation, June 2003, p.55) has disappeared:

> ...the children have greater flexibility in the organisation of the materials ... permits anyone to get parts as required and no longer insist on only one from each group...the models [are stored] on an open trolley and children allowed to work at various times when they have completed other work. The classroom resembles a workshop and ...children circulate freely and consult with other groups. Parts are shared and are less organised than before. (Richard's Master's dissertation. 2003, p.87).

### *Intervention and Assistance: Teacher or Peers?*

Richard's perception of his new pedagogical practice did not quite play out with some of his interactions with various children when they needed help. He says that he was "filled with awe at the resourcefulness of children when confronted with problems with which [he] can provide no assistance" (Richard's Master's Coursework, November 2002, p.4). And as he tried to define his new teaching role with regard to how, when and who should provide assistance, he identified with Vygotsky's (1978) theory of the zone of proximal development. But he seemed to believe that only "the teacher becomes the person who intervenes in the process." (Richard's Master's coursework assignment, November 2002, p.5). In his mind, the teacher retained all the power in the teacher-student relationship. He found it hard to recognise that students could help each other as well as he could help when assistance was required.

Richard described his new understanding of his role in preparation for a group discussion with the other members of his Master's group (Master's group discussion, October 2002). His description triggered a long conversation in the seminar group about ZPD and classroom intervention by others rather than the teacher (i.e., peers, other adults). But despite this probing and reflective discussion, Richard continued to regard himself as the primary source of scaffolding for his students' classroom learning, possibly because his students that year were in their first year working with the computational materials, whereas Richard was in his fourth EM year.

In the beginning of the EM project, Richard himself was trying to come to terms with the materials and was trying to solve the problems with the children. Now, however, he was back in the traditional "expert" role, knowing more than the children and, in effect, reinstating his power in the relationship. He had forgotten that when he was first working with the materials, often the children—not he—had influenced problem-solving, as in the case of the Black Line Problem. After three years, he had experienced many common problems of novice builders and believed he could intervene to help them with their projects. This mode of thinking was dangerous because he might intervene too soon and not give the children sufficient time to try solving the problem for themselves. So he had to exercise restraint and be careful of his timing, questioning, and interaction with the children.

Gathering data from his interactions with the children, and reflecting upon them in order to analyse his changing role as he wrote his Master's dissertation, was a fruitful learning experience for Richard. He stood back from the immediacy of the classroom activity to examine his perceptions, wondering how his interventions influenced the children's thinking, and whether he might be, in fact, too directive. He recorded his interventions (text, voice recorder), which then became the focus of discussion with me, and in a small, independent discussion group with two other fellow EM graduate students who all wanted to emulate the discussions they had during EM workshops. They valued these discussions as a means of reflection and a mechanism for encouraging alternate perspectives (McLaughlin & Talbert, 1993; Darling-Hammond, 1996; Hamilton & Richardson, 1995), so their discussions promoted a depth of reflection that reduced the possibility of self-delusion, which helped Richard understand his emerging new classroom role more clearly. He began to realise that on occasion he was

> too directive . . . [and] need[ed] to be more mindful of allowing the child to respond at greater length before I comment . . .[and] should let them discover . . . problems for themselves. I recognise that this is something I need to be more cognisant of in the future" (Richard's Master's dissertation. 2003, p.94).

Richard also became more aware of the possibility of the children's peers acting as a source of help and assistance. Rather than always providing the assistance himself, he began to direct children to other groups' constructions that could be useful in solving their own problems. For example, when the children were working on their self-selected theme of "Dublin of the Future" (February 2003), a group who was building a large crane needed "to get lifting power and speed control." They knew "gears [would] provide this power so I advised them to look at the gearing solution the group building the bridge had used" (Richard's Master's dissertation, 2003, p.89). And when Richard finally got the long-awaited network connection in his classroom, he began to use examples of other children's work that had been posted by other schools on the EM group's website (http://empoweringminds.mle.ie). For example, when a particular design

> would not allow the vehicle to turn, as the wheels need to be able to rotate at different speeds through the turn, I remembered that another teacher had posted a photo of a differential gearing solution on the Empowering Minds website and I directed the boys to this site to investigate differential gearing. . . . Once they understood the gearing, they built their own appropriate solution for their model (Richard's Master's dissertation, 2003, pp.100-101).

Richard might sooner have realised the potential of peer assistance had he been working with children whose experience was cumulative from year to year as were Tommy's. In such circumstances, he might have found himself plunged into learning situations where he could not provide suggestions towards a possible solution, but the children might have done so—and he would have been his students' co-learner once again.

## *In Conclusion*

Richard says his involvement with the EM project has "challenged me a lot to think about what teaching is" and that he has "changed substantially" his beliefs and assumptions about teaching and learning. "Prior to the project" he believed that the teacher was "the person with a body of knowledge who disseminates it" " (Interview, December 2002). Nevertheless, he has developed from being a teacher rooted in a very traditionalist approach to a teacher who believes in a Constructionist philosophy of learning. He no longer regards knowledge as a fixed entity to be transmitted. He regards his students not as knowledge consumers but as knowledge creators who construct their own understandings. Because he has greater tolerance for ambiguity and uncertainty, he no longer feels he must control every aspect of the learning environment. He has shifted his understanding of the learning process and his role as a teacher:

> My understanding of teaching was . . . you have a body of knowledge that has to be done, you have to get the book done . . . whether you want to do it or not. That has changed. I don't feel like that anymore. . . . I feel I have to give children credit for . . . being able to do things on their own . . . to learn and create their own knowledge. I don't have to be the one that does that anymore. And I don't think there is a thing out there that has to be assimilated at a certain point. We all learn at different levels (Interview, December 2002).

### *Extending the New Teaching/Learning Approach*

Richard has relinquished more control of their learning process to the children, and "this way of working was not confined to just working with the EM materials" (Richard's Master's Dissertation, June 2003, p.83). He has begun to implement this approach in many other aspects of his class work:

> In music lessons, the children used percussion instruments to discover their own rhythms and create their own sounds. In a science lesson . . . the children created a simple circuit with a battery, light bulb and wires and then . . . used more than one bulb and more than one battery to experiment on the different effects that could be achieved. . . . For maths activities, . . .

> children work co-operatively when solving ,problems and I no longer insists on everyone working on their own. (Richard's Master's Dissertation, June 2003, p.83)

When he came to the EM project, Richard "used to feel that you couldn't let kids off on their own doing things because you didn't know what they were doing, and you couldn't monitor what they were doing." But now he doesn't "have that fear anymore" and is "quite prepared to let kids off in other areas. . . I don't feel that I always have to be watching to see if they are learning or what they are learning" (Interview, December 2002).

### *Cyclical Spiral of Action and Beliefs*

Huberman (1995) has recognised the need for support for teachers and a period of time to allow for development of ideas: "[N]either clarity of practical understanding nor appreciation of the significance of an innovation fully develop until teachers have gained some experience in trying it out in their own classrooms" (Huberman 1995, p. 249). Richard's development over the five years of his involvement with the EM project can be described as a cyclical spiral of actions and beliefs. His decision to become involved in the project was the catalyst that led him to question his formerly entrenched position as a traditional teacher. In this, he is very much in keeping with Lindberg's claim (1995) that that although belief must underlie a permanent change in human behaviour, belief is most likely to follow behaviour rather than to precede it. Therefore, motivating individuals to take action or to behave in certain ways is perhaps a more efficient starting point than trying to change beliefs so that behaviour will follow. But they need the action they take to be coupled with a supportive environment (See Table 11).

The combination of computational materials and the Atelier-style learning environment ignited the spark for Richard to begin thinking about learning. It may appear strange, in retrospect, that he really began to question how learning happens only after more than 25 years in the classroom. But, as he admits, "you get comfortable with things" (Interview, December 2002). Richard himself directly makes the connection between the activity he engaged in with the computational materials (both at workshops and more particularly in the classroom) and his changed perspective on learning.

Table 11: *Cyclical Spiral of Close Linkage Between Richard's Actions and Beliefs*

| **Action** | **Beliefs** |
|---|---|
| Involvement in EM project – using the computational materials in class | Assumptions about learning are challenged (significant events) |
| Begins to loosen control. | Affirmation of action as he witnesses more evidence of powerful impact of this way of learning; becomes more convinced; needs to understand more as existing beliefs do not match what he is witnessing. |
| Decides to participate in a Master's programme. | Readings & reflection help him understand what is developing in his classroom. He now has a language to describe the learning environment and his changing role as a teacher. Begins to believe in children's ability to take ownership and control of their own learning. |
| Children given more control of the learning process and teacher acts more as a facilitator. | Children can construct their own knowledge and are capable of being self – directed learners. Teachers do not have to have all the answers but can continue to learn themselves and as co-learners with their students. |

> If somebody had lectured me and said 'read this, this is the best way, the new way to teach. You should really give it some consideration'. I don't think I would have really. You have to experience it yourself. The project did that, it put me back in a learning situation, threw me in with the kids and we were all trying to learn together. That was different from before where I would have been in control of things. I wasn't so much in control as I was trying to learn with them. It made me think 'how do we learn?' (Interview with Richard, June 2002).

This desire to understand learning was what motivated Richard to begin a post-graduate programme and take time out to read, reflect and build his own understanding of learning.

> ...as time progressed and the kids got involved in the project it definitely became clear that there was new learning taking place here. There were things I had to think about (Interview with Richard, June 2002).

Research papers and other reading material had been available at the Summer workshops (August 1999/2000/2001) Richard had participated in prior to this decision to begin a postgraduate course. However he freely admits that he did not have any interest in reading them, as he was not ready to embrace the questioning of his own learning beliefs and assumptions. This is consistent with Knowles' claim that adults only "become ready to learn those things they need to know and be able to do in order to cope effectively with real-life situations" (Knowles, 1998, p.67).

His experience in the Welsh school system presented profound challenges to his understanding about learning. With its emphasis on group work and project-based learning, the Welsh system stood in direct contrast to Richard's very traditional background of whole-class, textbook-based teaching. But rather than his teaching there being a positive or emancipatory experience, "it was very hard to see what they were doing," so he felt that the Welsh "had really lost the picture . . . and the kids were learning nothing" (Interview, December 2002). As a result, he became all the more entrenched in his very traditional outlook, where the teacher was very much in control:

> This is a disaster, what is happening over there! And God help us if we ever go down that road! . . . [so] I went back to what I was familiar with, and I started whole-class teaching, using books and making sure they were learning things. It seemed to work, as far as I was concerned, and parents felt their children were learning (Interview, December 2002).

Without the support of a community that could help him understand the rationale behind the Welsh system, Richard naturally reverted to what was familiar, as he felt inadequate, threatened, and isolated (Rogers, 1969):

> Teachers often feel very isolated. Teaching has always been a very closed occupation. You go in, you close the door, you do your thing, and you walk out. Teachers rarely discuss things, maybe because they don't like talking about their own inadequacies (Interview, December 2002).

Empowering Minds offered Richard a precisely opposite professional atmosphere. There, he found a different environment where his classroom experiences (Warren-Little, 1993, p.138), coupled with a supportive framework (Showers & Joyce, 1996; Darling-Hammond, 1996; Caccia, 1996; Raywid, 1993; Ruiz et al., 1995) designed and developed in response to the group's learning needs and interests (Lindeman, 1926; Tannenbaum et al., 1991; Freire, 1970), sustained him as he began working with the new computational materials. Consequently, he evolved into a self-determined learner (Candy, 1991) with a radically changed perception of learning and his role as a teacher.

> When trying new ideas with children, the teacher needs a supportive framework of colleagues as doubts or uncertainties can only be resolved through discourse. . . . The framework to do this was established in the project through the discussions and meetings of the teachers involved. The project director was aware of the challenges teachers would experience

> and regular contact was facilitated to provide support (Richard's Master's dissertation, 2003, p.38).

### *Collegial Support*

Within the EM project, Richard values his membership in a supportive community (Showers & Joyce, 1996; Darling-Hammond, 1996; Caccia, 1996; Raywid, 1993; Ruiz et al., 1995) that communicates honestly and in which he feels safe admitting to fallibility as a teacher:

> There is an empathy between people. We are all in it together, we all learn together and we learn from each other. . . . This has certainly made you talk about your inadequacies because they very quickly come to the surface in this project very quickly. The only way they can be overcome is through communication. (Interview with Richard, December 2002)

Because the EM group is democratic (Tannenbaum et al., 1991) in how it operates by respecting individuality while also accepting and encouraging dissent (Warren-Little, 1993, p.139; Sugrue et al., 2001, p.39; Grossman & Wineburg, 2001), Richard believes that EM fosters real professional and personal growth:

> I think everybody's view is taken on board in the group. I think everybody is very skilled at listening to what others have to say and taking it on board. They might not always agree with them. Or might not want to pursue it themselves. Certainly everybody is very respectful of each other's opinions and listens intently to what people say (Interview with Richard, December 2002).

Supported by this framework, Richard feels safe (Maslow, 1972) and has come to acknowledge and accept his own shortcomings:

> You don't feel that anybody will have all the right answers, or that somebody will be critical of something that you did. You are not going to be criticised for it. . . . People are comfortable with each other and so will communicate with each other (Interview, December 2002).

Because he was part of the decision-making process, Richard felt in control. In EM's collaborative process, his input into the project's development (Freire, 1970) had been taken into account, so he believed he had been part of an innovation in which his expectation, along with everyone else's, had been achieved through mutual planning (Tannenbaum et al., 1991):

> In a new project like this, it was new for everybody, and obviously we had some concerns. One at times felt, "What am I doing here? . . . I'm going to give a lot of time to this!" . . . . So it was very important to be involved from the outset in all the discussions on what can be done and how it

> should be done, and what the themes were going to be, et cetera—very, *very* important (Interview, June 2000).

Richard also highlights the importance of having other teachers in his school as members of the EM project group working with the computational materials in their classrooms:

> I wouldn't think it would work well for a teacher on their own in a school trying to do this, as it's very important that there would be one or two others to talk to about it, or to work with and to share frustrations with at times—very important (Interview, June 2000).

The teacher-partners within his own school were particularly important in the first years of the EM project's development as it took time to establish trust and acceptance among the other members of the group. These teachers built solidarity as they met at workshops and group meetings over a number of years.

### Continued Growth

As Richard enters his fifth EM year, he continues to question and reflect on his practice. Having laid many of his earlier concerns to rest, he is more comfortable with his emerging role as a co-learner with his students. He is no longer fearful of repercussions as he has received positive parental feedback, particularly from those whose children had difficulties at school prior to the introduction of the computational materials.

He believes that his students' sustained engagement and persistence in tackling problems is testimony to the fact that the Constructionist way of learning is far more relevant and meaningful them than the traditional approaches he employed for so long. As his learners' needs and interest productively inform the learning process, he relies less and less on textbooks and no longer feels threatened when his colleagues "cover lots of content." He has shifted his focus from exclusive product-focus to the learning process of learning and the importance of designing computationally-rich environments that conduce to the development of diverse learning styles.

He persists in his efforts to understand learning and "to learn about how the children organised themselves." He pays close attention to the interaction of diverse children and groups, frequently asking them to explain how "they work in a group with regard to discussion, designing, building and overcoming problems" (Richard's Master's dissertation, June 2003, p.84).

In his quest, Richard makes use of a variety of digital tools (camera, video camera and voice recorder) to capture the learning process, all of which helps him think about thinking:

> Motivated by the strong desire to capture the learning process I was observing, I learned how to use these tools and completed a course in digital video editing, as I realised that this media was the most powerful way to record what was happening in my class (Richard's Master's dissertation, June 203, pp.87-88).

His experiences of working with the children over a number of years has helped him realise the potential of these expressive computational materials as a motivation for communication; a means of social integration; a mode of expressing meaning; and a mechanism which promotes sustained engagement with problem-solving. This reflective thinking has helped him appreciate different learning styles and accept that there are multiple ways of expressing meaning. It has also challenged him to question traditional evaluation techniques and accepted definitions of what school values as being "smart" (Warren-Little, 1993, p.139).

Now, Richard has a language to describe learning (Roth, 1999) derived from his student's work with the computational materials, so he confidently endorses Constructionist principles as an aid to learning, along with his changed role as a teacher as he relinquishes progressively more control of the learning process to hi students. He has replaced his obsessively-controlled didactic classroom, in which children worked on very specific product-focused tasks, with a more relaxed workshop-like environment that focuses directly on contexualised projects that the children have chosen. Although Richard sets some tasks, they are very open-ended and non-prescriptive as to approach. Materials are freely accessible at all times rather than being locked away and available only for specific timetabled sessions. His students work in self-selected, fluid groups, or alone, rather than in teacher-mandated arrangements, and their discussion, critique and sharing of ideas (Kuhn, 2001) are a distinguishing feature of their work.

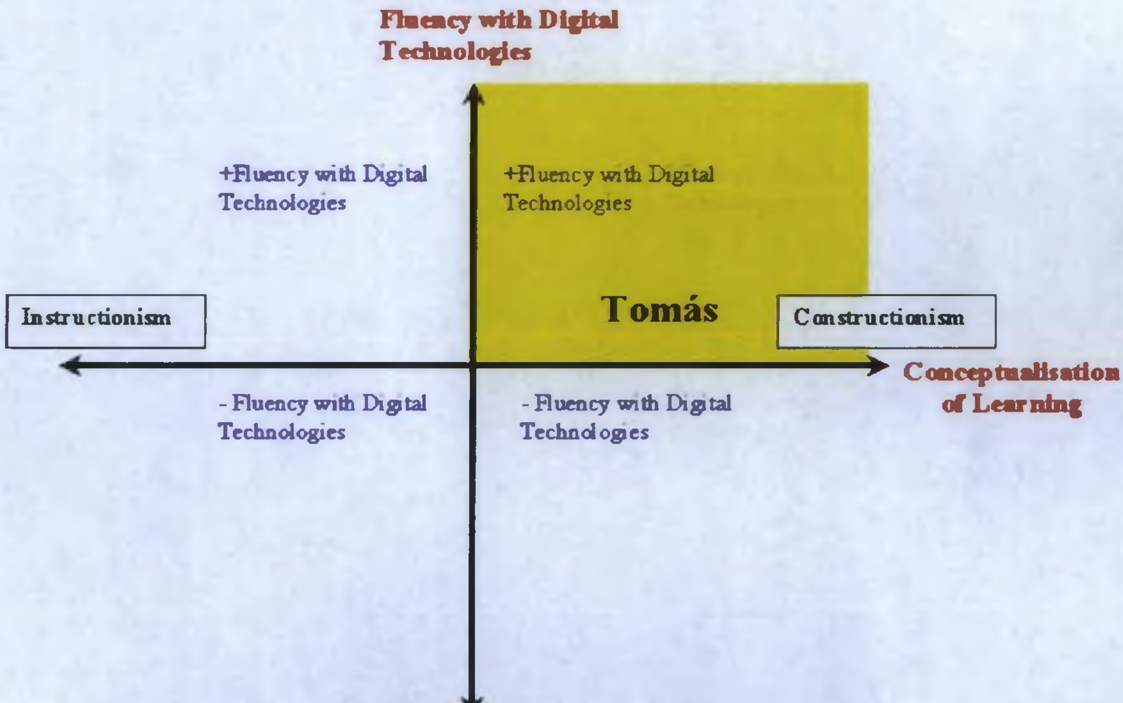
Richard has "become a more open-minded and reflective teacher." His involvement with the EM project "has been a journey of self-discovery and new learning for me, as my perceptions about teaching and learning have been challenged, and I have had to assess what I do, and why I do it" (Richard's Master's dissertation, June 203, p.107). He attributes this challenge to the "routines and comfort zone in my teaching" to "the nature of these computational materials" that catalysed his transformation into "a co-learner with my pupils, when their problems became my problems" (Richard's Master's dissertation, June 2003, p.108). In the supportive framework of the EM project, he was able to examine\ his practice "and look for ways to change and improve it" (Richard's Master's Dissertation, June 2003, p. 110). He believes that reflection is the key to change: "It is too easy to develop stale but comfortable methodologies in the classroom, where we think everything is going along nicely and we are doing our best. The reality is that we need to be challenged." (Richard's Master's dissertation, June 203, p.110). But this reflection, that "should be at the heart of a teacher's practice . . . can best happen through working at something that challenges how we think of ourselves as teachers" (Richard's Master's dissertation, June 203, p.111). So the linkage between teachers' daily reality in the classroom and their beliefs is extremely important, and must become the focus for reflection. When these computational materials are embedded in the activity of the classroom (Warren-Little, 1993, p.138; Sugrue et al., 2001, p.8), the teacher's practice becomes "an object to think with" (Papert, 1980). When Richard grounded the computational materials in the everyday reality of the classroom , Richard commened the ongoing process of "learning about learning" as he struggles "to relinquish [his] old traditionalist approach" (Richard's Master's dissertation, June 2003, p.111).

He has truly begun the self-directed process of continual questioning and revision of perspectives on practice that Cranton believes to be "the essence of professional development for educators" (Cranton 1996, p.116). He has now stepped beyond the boundaries of his own classroom and is extending the learning culture of the EM community. Since September 2003 another new teacher is using the computational materials Richard originally used and is being supported by the other EM teachers in that school. Richard has become the co-ordinator of a new learning initiative within the Digital Hub that developed as a direct result of the EM project. He will be working with 11 primary schools and five post-primary schools in a disadvantaged area of Dublin using expressive computational materials informed by Constructionist principles. Richard embraces this exciting challenge with great enthusiasm and deep commitment because, as a result of his EM involvement, he now knows—as never before—what he is doing in his profession, and why he is doing it.

# Case Study 4: Tomás
## *The Risk Taker*

> School . . .is a place where teachers do not provide information. The teacher helps the student find information and learn skills—including some that neither knew before. They are always learning together. The teacher brings wisdom, perspective and maturity to the learning. The student brings freshness and enthusiasm. All the time they are all meeting new ideas and building new skills that they need for their projects. Some of what they learn belongs to the disciplines school has always recognized: reading, writing, mathematics, science and history. Some belongs to new disciplines or cut across disciplines. Most importantly, students and teachers are learning the art and skill and discipline of pursuing a vision through the frustrating and hard times of struggle and the rewarding times of getting closer to the goal (Papert & Caperton, p. 2, 1999)

*Figure 56:* Tomás: Digitally Sophisticated, Open to New Learning




### *Introducing Tomás*

Tomás has been teaching for 29 years, 19 of them as principal of a rural, two-teacher school in the parish next to the one where he grew up. Prior to this he had taught in a number of larger town schools. In addition to his position in the school, he is an active member of the local education centre, and a facilitator of an online discussion forum on the teacher union website. He is also a course tutor for the NCTE, and an outreach postgraduate diploma in technology from NUI, Maynooth. In his "spare" time, Tomás coaches a local senior hurling team as well as the school team. No matter how busy he is, though, Tomás always finds time to pursue a new idea with great passion if it captures his interest or serves a personal need.

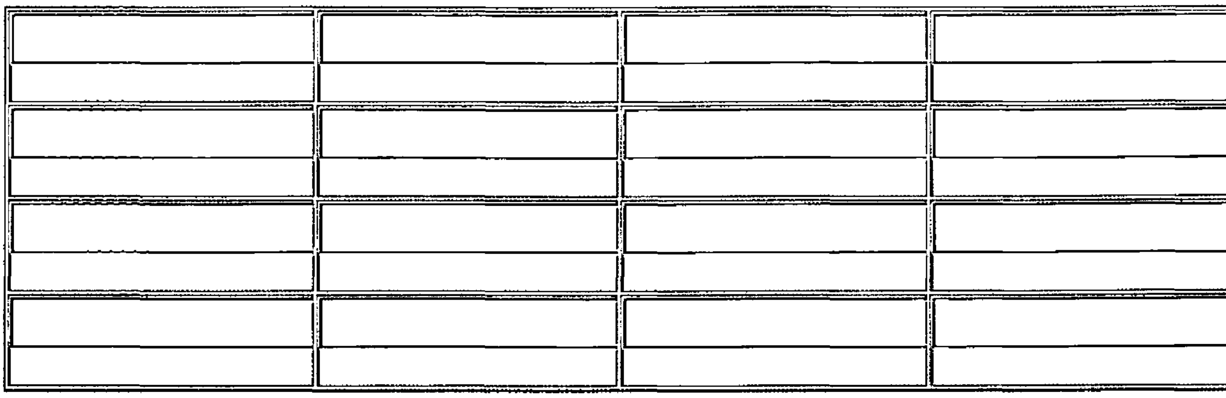
In his rural, two-teacher school, Tomás teaches children aged 8-12 years in the middle and upper primary school, and Mairead, his wife, who has been at the school a year longer than Tomás, teaches junior classes—infants, first and second classes, children ages 4-8 years. With this arrangement, each has a mix of ages as well as four different grade levels, each with its own curriculum requirements. Teaching multiple grade levels is a substantial challenge; meeting the curriculum objectives of each grade level is particularly daunting. Tomás was aware of the fact that in attempting to cover the requirements as he taught one grade level, he often set the other grade levels work that was in effect "busy work" that merely marked time until he could get around to teaching them. He explains,

> In the multi-class setting . . . you're usually only dealing with one class or one group at a time, or maybe sometimes two classes at a time. So the others are engaged in some sort of work. But with the best will in the world, that work would often just be time-filling exercises. (Interview, July 2003, pp. 5-6)

Parents expected Tomás to cover the curriculum and to prepare their children adequately for entry into the "top streams" of the local second-level schools. He was not comfortable with the narrow view of education a lot of the parents had. Though he felt constrained by their expectations, he did manage to move beyond their perceptions of what education should be, by engaging in occasional extended projects. The projects had substantive connections to required curriculum; additionally, they provided opportunities for students to explore specific topics in depth.

Tomás loves a story and is a mine of fascinating tales, which he tells passionately and in great detail. He is fervently interested in local history and was part of a small team who published a very successful history series for use in primary schools. Just prior to becoming involved with Empowering Minds, Tomás and the children had spent lots of time compiling a large project on their local community's history. "The Way We Were" details what life was like in this rural area in the time of the children's grandparents (See Figure 57). This project can now be accessed on the school website.

*Figure 57:* Navigational Menu for *The Way We Were*, Community-Based History Project



Acutely aware of the isolation factor inherent in a rural, two-teacher school, Tomás broadened the children's perspective and awareness of other communities by involving "The Way We Were" in a European-funded Comenius project called "Sharing Our Past: Sharing Our Future." Tomás coordinated this project, which involved schoolchildren in three other countries: from Volksschule Kalkleiten and Vaolksschule Stiwoll, both near Graz, Austria; from Gateskolan in Arvika, Sweden; and from the Nursery and Primary School near Iraklion, in Crete.

Through the Comenius project, Tomás saw an opportunity to bring together a number of strands under the umbrella of exchanging national myths and legends. Besides addressing the curriculum objectives in geography and history (thereby keeping parents happy), Tomás knew the Comenius Project would help his students develop computer skills. They used PowerPoint to make slide shows incorporating text, sound and pictures of their favourite legends, which they then sent by email to the children in the other European schools, who reciprocated with their own materials. Pleased with the Comenius project, Tomás submitted a version of the idea to the NCTE as an individual-school project to be funded under the SIP initiative in 1998.

## *Tomás's History With Computers*

Out of personal interest and curiosity, Tomás got interested in computers in the early 90s. He bought himself a computer to use at home and began dabbling in various programmes, teaching himself how to use them as he went along. He explains that he then took "some computer courses which were taught . . . not specifically with education in mind, but when once I started using them in the school, I started to see possibilities in that area" (Interview, July 2003, p. 1). Luckily, a parent of one of his students had a connection at Intel who helped Tomás buy a fairly up-to-date machine for the classroom, very reasonably.

When he got involved in the ICT Higher Diploma program (http://www.may.ie/academic/education/ict.pdf ), he started trying out new applications in class. The more he used the technology, the more uses he saw for it, and the more convinced he was of its merits in curriculum-related activities. He purchased two more computers for his classroom, and the children began using them daily, predominantly in word-processing and presentation software such as Powerpoint. Tomás's interest and use of computers in school with the children fed off each other. In order to deepen his own understanding of the subject, Tomás became an NCTE tutor, delivering ICT courses in the local education centre. And the year after he qualified for the Higher Diploma, he became a tutor in that programme as well.

### *How Tomás and Empowering Minds Came Together*

When the SIP's then-director, Seamus Knox, and I saw Tomás's SIP application for the extended version of the Comenius project, we got in touch with Tomás and sketched the Empowering Minds project for him. As a result of these discussions, Tomás decided to become involved, as he was intrigued by the computational materials we planned to use, and he was interested in finding out more about what they could do.

And Tomás had another major motive in joining Empowering Minds: he was attracted to the open, emergent approach we described to him. He found fault with earlier efforts at school reform that took the form of top-down mandates with minimal training and no long-term follow-up support or feedback to classroom teachers (Ruiz et al., 1995). This openness was clearly signalled from the outset by how the workshops were structured and the expectation that the participants were to determine the focus and direction of what was to be done. He was relieved that it wasn't at all like previous inservice courses he had participated in and liked the idea that the group could influence the shape and direction of the project from the outset (Tannenbaum et al., 1991; Freire, 1970). This stood in direct contrast to other programmes which had a tendency to promote the 'one best way' prescription for all schools, "regardless of local traditions, values, needs and interests" (Sergiovanni, 1999, p.76).

> We were allowed to form the project ourselves and have an input into it. Then even as the project unfolded each school followed its own lines as to how it would apply the project not just in each school but in each

> classroom as well. That was one way in which it was different and attractive ...to me anyway. (Interview, July 2003, p.2)

Tomás doesn't "like being dictated to" (Interview, July 2003, p.2). Having control in the way EM promised was important for him; the more he felt ownership of the project, the more willing he was to become engaged with it. He had never been comfortable with others making decisions which affected his classroom practice, as he explains: "I was never comfortable with things handed down from on high. If too many people high up band together and hand something down, I'm naturally suspicious of it from the outset (Interview, June 2000, p. 22). In nearly 30 years in the educational system, Tomás has become wary of ideas or curriculum reforms prescribed by outside authorities while offering "no support when you try to implement their ideas" (Bolam, 2000, p.278) particularly when he faced difficulties:

> Well, I suppose if you look at things that come down from on high and when you're teaching, particularly in a rural school with 4 classes in front of you, and when you do have any difficulties or any problems, and you ask and you send a request up the ladder to find out how to do this nobody knows, they all tell you that you have to make that judgement for yourself! So if people are telling you, on the one hand, that they don't know how to solve your problems, and on the other hand, saying "This is what you must do," it doesn't sit well with me anyway. (Interview, July 2003, p.2)

Tomás was so dissatisfied with reforms and changes demanded "from above" that he would not have volunteered his participation in EM if he had the slightest suspicion that it would be dictated "from the top." As he says, "I probably wouldn't have done it if it wasn't for . . . the scope to use your own initiative and to put your own stamp on it. (Interview, June 2000, p.11). Tomás might also have resisted if the project hadn't foregrounded the freedom of learners to set their own learning goals. "If we as teachers," he explains, "couldn't put our stamp on it, the chances are the pupils wouldn't be able to put theirs either (Interview, June 2000, p.11). Because, as Carl Rogers (1969) suggests learning should be personally meaningful and relevant, as a person learns only those things that they perceive as being involved in the enhancement of self.

He also realised the value of EM's respect and allowance for individual interpretation because "if somebody else sets the goals and sets up the means by which you should achieve them, then they'll never be yours" (Interview June 2000, p.11). He already knew this in relation to his own learning. However, during the course of the EM project's development, he came to realise and believe that children also are capable of setting and achieving their own learning goals.

Tomás was acutely aware of the fact that each school context was different and "that what would be appropriate in one classroom setting wouldn't necessarily be appropriate for all" (Interview, July 2003, p.3). His view is entirely in keeping with principles outlined by Warren-Little (1993, p.138) that stress that professional development should take explicit account of the contexts of teaching and the experiences of teachers, affording them a means of locating new ideas in relation to their individual and institutional histories, practices and circumstances. This principle challenges the context-independent or "one-size-fits-all" mode of formal staff development that introduces largely standardized content to individuals whose teaching experience, expertise and settings vary widely, but never are taken into account in the design of inservice training programmes. Tomás was greatly encouraged by the fact that the EM developers shared his views: "They . . . knew that from the outset . . . the one-for-all thing wouldn't work" (Interview, July 2003, p.3). He deeply appreciated the fact that each teacher was to develop the project as they saw fit for their own classroom context.

> With the project, we always felt from Day One that when we brought back the materials to the school that we'd have licence to pursue it in our own way and make our own mistakes and make our own developments and then compare notes with others and see where they were going (Interview, July 2003, p.2).

When Tomás realised that EM would accept difference, and encourage it (Grossman & Wineburg, 2001), he was even more resolved to engage wholeheartedly with the project's principles.

## *Choice of Partner*

Unlike the other schools involved in the original EM group, Tomás's had only two teachers, so he was limited in his choice of partners. On the plus side for his colleague, she fitted the criteria for selection: Mairead was female, she had no computer experience, and she taught junior classes. However, she was more than a little anxious about her complete lack of computer experience. But she was encouraged when we reassured her that she was exactly who we wanted, that her EM colleagues would include other teachers who had no computational experience, either, and that she would have all the ongoing classroom support she wanted. Because she teaches junior children, much of her curriculum already involved manipulating materials, so she was intrigued by the type of computational materials we proposed to use. Bolstered by this interest and the promise of support, coupled with the assurance that she could withdraw from the project at any time, Mairead consented. So both Tomás and Mairead became part of the original group of nine teachers who volunteered their involvement in the first phase of the EM project group (March 1999-June 2000).

## *Tomás in the EM Workshops*

Whatever he's doing, Tomás is insightful and can focus on the "big picture" while quickly grasping the kernel of a problem. He constantly makes connections and asks probing, often difficult questions as he tries to understand new ideas. Because he thinks deeply and turns over the pros and cons of any decision, he is not afraid to take risks, for he is prepared to deal with their consequences, whatever they may be. From the outset, Tomás was open and enthusiastic about using the computational materials and felt very comfortable with the Atelier-style workshops because "it gave me a chance to explore the materials and to explore the possibilities and discuss them" (Interview, July 2003, p.5). This method of working "suited me as we were able to get in, dabble with the stuff and talk about it and in that way maybe see more possibilities for it." Consequently he "enjoyed the structure" and "liked the workshops that way" because he does not "like things that are so structured as to steer you down a certain preordained channel and determine what you are doing" (Interview, July 2003, p.5). For Tomás, being actively involved in the learning process meant his experiences were meaningful, and his motivation levels rose accordingly (Ruopp, 1993; Thompson et al, 1992, pp.11, 68; Thornburg, 1994, pp.24-25).

Although absorbed in exploring the materials, Tomás was also conscious of how others were reacting. He was aware that although he was comfortable with the structure of the workshops, "they may not have suited other people that way" as others "might have liked them to be more structured because they were uncomfortable with the materials or how they were going to go about it in the classroom" (Interview, July 2003, p.5). Aware of others' reactions to the materials and to the workshop format, Tomás readily understood their difficulties and concerns as they learned—and then as they began to think about introducing the materials into their classrooms. He also interested himself in other people's alternative views as stimuli for his own new learning (von Glasersfeld, 1989); they alerted him to problems he might face with others (not necessarily the children, but their parents and the school authorities) when he returned to his own classroom.

### *Influencing the "Theme" Decision*

The literature on adult learning (Lindeman, 1926) suggests that teachers' own personal needs and interests, coupled with their experiences in the classroom, should form the starting point around which to challenge and build new ideas and perspectives on learning. Tomás's prior experience with the collaborative Comenius project and his deep interest in history were extremely instrumental in the choice of focus and direction of the EM teachers' use of computational materials.

Towards the end of the first-phase summer workshop (1999), the teachers began to feel a need for a unifying focus, a theme around which the project could be structured. However, Fred Martin disagreed, and voiced his opinion gently but forcefully at several group conversations. He was concerned a theme would restrict the use of the computational materials by, in effect, binding them to a curriculum. Conversely, the teachers—particularly Tomás—believed a theme would provide a context within which their explorations with the computational materials could take shape. They felt they could not proceed in a vacuum and that the classroom work would have to be rooted in some tangible context. They acknowledged that this theme would have to be broad enough to encompass all interests and different school settings. They did not want to be squeezed into a narrow structure that would not allow interpretation and development (Observation field notes, day four, August 1999).

Aware of the teachers' apprehension about working with the materials in class, we had arranged for John Bilotta to work with them for the weeklong summer workshop. John—an elementary teacher of many years' experience, now the technology co-ordinator for a school district in Rhode Island—had worked in classrooms with the prototype of the Programmable Brick, identified closely with the teachers' concerns, had invaluable experience, and could offer advice and suggestions.

In fact, John triggered the theme idea when he explained how he had structured a project at Peacedale Elementary School in Rhode Island. Taking off on *Jurassic Park,* Robotic Park had two quite different aspects: (1) a task-oriented challenge that varied in content from year to year; in May 1999, it was "The Chip Challenge," in which remote-controlled or autonomous robots competed against the clock and each other to gather chips from a game board, and (2) an installation in the main school hall, called Robotic Park, an imaginary zoo and theme park featuring student-designed and – built robotic creations that aimed to imitate behaviours of real animals in their natural habitats. The children researched their chosen animals' environments and behaviours, and developed elaborate and sophisticated displays and robotic creations. Eagerly, the EM teachers questioned John and me (I had visited the exhibition) at length about the types of projects the children developed. Clearly stimulated by our descriptions and explanations, they eagerly viewed the many photographs and video footage I had taken of the children's work.

Tomás quietly asked a few questions and closely examined an exhibition booklet that had short descriptions of all the projects that the different schools had displayed (Observation notes, day four, August 1999). Not one of the teachers was interested in the competition element, as they felt there was more than enough of that in schools already, and they did not want these new materials identified with yet more competition' (Observation notes, Day Four, August 1999). But they were taken with the idea of a unifying theme or framework in which to situate learning experiences, and they pursued the idea in subsequent group conversations.

Tomás listened quietly while many ideas were proffered. Cliff strongly proposed an "Outer Space" theme, as he felt we should be forward-thinking with these new materials. One young female teacher agreed with the idea while many were undecided. Two other female teachers were most concerned that this theme was very male-oriented, so could exclude many of the girls in their classes. Others felt "Space" was too narrow and would produce too many similar projects that would not demonstrate the full diversity of the materials. Each member of the group mulled over the problem, and a few other futuristic-type themes were suggested.

Then Tomás, who had not yet spoken, acknowledged the others' anxieties about limitations and curriculum standards, and he suggested a mythical theme. He declared his love of history and explained the Comenius project he and his students currently were involved in. Tomás explained that besides being selfishly interested in expanding what he was already doing, he felt this theme was wide enough to be explored by everyone at many levels. He cited his students' delight in the project to date: besides igniting interest in their own traditional myths and legends, they were enthusiastically engaging with the myths from the other countries, and were involved in a host of other cross-curricular activities—exploring the similarities/ differences in myths; illustrating scenes from the stories; investigating where the myths took place.

Tomás's remarks launched a long discussion of our Irish oral tradition and the imminent danger of losing many of our fine stories and traditions amid this rush to encompass the "new technological age" (Observation notes, day four, August 1999). After lots of to-ing and fro-ing, the group decided to settle on the wider theme of "Story, Myth and Legend," capable of truly broad interpretation and naturally synergistic with the Irish tradition of storytelling. And of course, once they got going, they soon realised how many other cultures tell stories, too. This strong identification with story however is not uniquely Irish as members of the group found out from subsequent exchanges with teachers of other nationalities. They realised that storytelling is a natural and very powerful means of expression and communication.

Just about everyone, felt "Story, Myth, and legend" could be a very powerful theme. Rather than having compartmentalised units, a thematic approach would allow the freedom to make choices to suit the interests and the needs of each teacher's own school context. Not everyone matched our enthusiasm, of course: Cliff and Fred both felt that "Story, Myth, and Legend" was so broad that it would not add anything of great significance to the classroom work. Now, though, Fred acknowledges that he "could not have imagined the richness and depth of the projects" the students developed from this theme (Field notes, April 2000). With the theme as a central locator, each teacher could take explicit account of their own context while also sharing a context in which they could communicate and support one another. They could each use their own classroom practice and experiences as "an object to think with" (Papert, 1980), to communicate and build a shared understandings of what being digital in learning could mean. Tomás's suggestion thus led to a key component of EM's emergent design.

### *Alleviating Tensions and Concerns About Time.*

Towards the end of the summer course week, as the time to return to school loomed closer, the EM teachers became urgently concerned with the practicalities of using the materials in their classrooms. From their own workshop experience, they knew they would need several classroom hours per week if the children were to construct anything worthwhile, and they worried about negative reactions they might get from parents and school authorities if they spent time using the computational materials and "neglected" what these groups saw as "the real business of school and what a teacher should be doing" (Observation notes, day three, August 1999). They were about to alter traditional patterns of working completely (Kleine-Kracht, 1993, p.393) and challenge the accepted "way we do it here" (Hord, 1997, p.37). The teachers anticipated conflicts as they recalled just how much of society believes that the only legitimate use of a teacher's time is standing in front of the class, instructing students (Hord, 1997, p.18). Round in circles they went, their feet getting colder as they inadvertently painted a bleak and negative picture of their futures in digital learning.

Just when they appeared about to talk themselves out of taking the risk they had originally seemed so excited about, Tomás quietly but forcefully challenged his colleagues to consider the reality of their classroom lives and to ask themselves honestly whether *everything* they did had a direct link to the prescribed curriculum, and whether they always used the official set time for each subject, for *that* subject. As the only principal teacher in the group, he was uniquely suited to ask this question; Tomás knows the realities of school life, the constant battle between outsider expectation and classroom practicalities. He asked them if they could honestly justify the amounts of time they devoted to externally-imposed, grade-level activities—First Communion or Confirmation; preparation for second-level entrance exams or aptitude/streaming tests; school concerts; Nativity plays and preparation for carol services; school choirs—and why they did so. Skillfully, he orchestrated an opportunity for the teachers to start questioning the experiences that had formed their "meaning perspectives" (Cranton, 1996). A lively discussion ensued, in which a range of topics came under the microscope, including:

- Who decides what is to be done in schools, and why it is to be done?
- Why are teachers not consulted about curriculum for the levels they teach?
- Is the existing curriculum sufficient to prepare children for the "Digital Age"?
- How is our work with the computational materials connected to the primary school curriculum? (Observation notes, day four, August 1999).

Such reflective discussions grounded EM professional development in a big picture of the purposes and practices of schooling, and let the teachers begin to interrogate, without fear, their individual beliefs and institutional patterns of practice (Warren-Little, 1993, p.139).

Then Tomás told the group a story he initially hadn't meant to share because he thought it might discourage them. But now, listening to the discussion, he suspected it actually would encourage them by illustrating the depth of his conviction about the classroom potential of these computational materials, given adequate time devoted to their use (Eraut, 1994; Huberman, 1995, p.249;) so that they give rise to new practices and the new cultures to support them (Caperton & Papert, 1999).

So he told the group that three children recently had been withdrawn from his school as a direct consequence of his introduction of the computational materials. Tomás was astonished by the parents' decision, as the father and the eldest child had attended the Easter workshop, where they had been the most enthusiastic participants and had constructed an elaborate model of an airplane, complete with moving flaps. The boy had continued working with the computational materials on his own, and his parents had reported to Tomás that they had never seen this child so happy and enthusiastic about coming to school because he could work with the computational materials there. Prior to the Easter workshop, the boy was very anxious about his schoolwork and had a poor self-image, but Tomás himself had remarked on the child's rapidly heightened self-confidence.

In the wake of so much positive feedback, Tomás was shocked by this family's abrupt decision to withdraw their children, and he was worried that it might be the start of a haemorrhage from his tiny rural school because the parents cited the EM project specifically as their motive for withdrawing their children. The forthcoming year would be their eldest child's last in the primary system. They felt this time should be spent on "basics" and preparation for entrance exams, so he could get into a good class at second level. Although Tomás reminded them about their son's increased confidence and self-esteem—direct results of working with the materials— and asked them if they were willing to sacrifice these accomplishments, they had already considered this, and—the sting in the tail—promised to buy the boy his own set of computational materials to work with at weekends if he worked hard in the new school. This way, they felt, their boy could have the best of both worlds.

Tomás and most of his students' parents had always had differing views on education, but those views had lain dormant until the EM project catalysed them into external conflict.

> Some of the parents would have been very traditional in their approach. Their view of education was very narrow and didn't extend too much beyond the three R's. Their idea of why they were sending children to school was very different than my idea of why they were coming. …as they felt the time taken from the basics was time wasted (Interview, July 2003, p.3)

The conflict, in turn, caused Tomás to assess his own convictions at the deepest possible level possible, and what place Empowering Minds had in his meaning perspective on teaching and learning (Canton, 1996, p. 96). It forced him to acknowledge the conflict of beliefs about education that existed between himself and the parents and the fact that "your performance in the classroom is judged on the kind of criteria that you wouldn't necessarily think much of yourself, but at the same time you have to live by it" (Interview June 2000, p.9). He deeply believed that the EM project "wasn't just something newfangled that would come and be replaced by something else. There was something genuine in it," and "it was worth giving it a try" (Interview, July 2003, p. 3). He and Mairead had discussed the issue at length and decided to continue despite possibly dire consequences.

When they heard Tomás's story, all the EM teachers immediately sympathised, but only when they calculated the percentage of his student population Tomás had lost could they appreciate the depth of his conviction and enormity of the risk he was willing to take: by the withdrawal of 3 of 37 children, Tomás had lost 8% of his school population. In an inner-city, disadvantaged school, and in medium-sized urban schools, this figure translated to approximately 20 children from each—and to more than 70 children from the large suburban school. These numbers were sobering, graphic illustrations of the length to which Tomás would go in order to give the ideas and computational materials of the EM project a fighting chance.

He finished by pointing out that if the EM strategy didn't work in their classrooms, they could always revert to the way they had worked before. All the teachers agreed to try the thematic approach, secure in the knowledge that their decision wasn't irrevocable but a means to tie the EM work to required curriculum. They knew their efforts would be supported, and their interests and concerns addressed.

Of ultimate importance to the study, however, Tomás and the other teachers made this crucial decision for themselves. So, from the outset, unlike other curricular reforms, EM teachers had full control over the ways they would use the computational materials, and full responsibility for designing the learning environments in their own classrooms. This is consistent with the social constructionist understanding of knowledge and the "Knowledge of Practice" conceptualisation of teacher learning (Cochran-Smith, & Lytle, 1999).

### ***Dealing Parents into the Empowering Minds Learning Environment***

Having lost 8% of his student population, Tomás knew all too well how important it would be for parents to experience and understand different ways of learning rather than think their children were "just playing with LEGOs" at school. When he heard John Bilotta describe the annual get-together he organised among all the theme-sharing teachers in his Rhode Island district, Tomás saw a way to address his own chief concern about parental attitudes while fulfilling the SIP funding requirement of dissemination of work done during the school year. He proposed that the EM group schedule a similar event on the theme of "Story, Myth and Legend" (Observation Field notes, Day 5, August 1999).

By offering this suggestion, Tomás again demonstrated his ability to be grounded in a big-picture perspective (Warren-Little, 1993, p. 139) while continually making connections among its parts (i.e., John Bilotta's experiences<—>the funding requirements<—>teachers' and children's isolation in a rural school<—>ramifications of parental attitudes). Hitherto, schools had not commonly come together to share learning; demonstrations of school-related work were usually some form of competition, such as ESB environmental awards (http://www.esb.ie/main/news_events/env_primary.jsp) and INTO handwriting awards (http://www.into.ie). So Tomás was thinking far outside a long-standing and presumably resistant box.

Some EM teachers favoured the demonstration idea right away while others had serious reservations because they were anxious about being on display in a way that would foster yet another form of competition, which all had agreed to avoid at any cost. From his perspective in an isolated rural school, Tomás bolstered his argument by suggesting that based on what they had learned, children would get to meet one another and learn even more from seeing each other's creations. Because if this idea of cognition as situated and distributed is taken seriously there are significant implications for learning, as knowledge is not the property of individuals that can be quantified, assessed or transferred in whatever way they see fit. Rather knowledge is distributed and situated in physical, psychological and social contexts (Brown et al 1989; Lave and Wenger 1991).What is also "important in coming to understand the dynamics within problem-rich learning environments is the notion of community of practice...[which are] characterised by the shared practices, (linguistic) conventions, behaviour, viewpoints etc." (Roth 1999, p.16). Parents, too, he argued, would be gratified to see that other schools—not just their own—were involved in EM, and that a prestigious third-level institution was backing the project.

Sensitive to the concerns of some of the teachers that they would feel uncomfortable about a 'big event' and that others may not have the same concerns about the importance of parental involvement, Tomás suggested that each school schedule an earlier local function, to which project directors and the local community in general would be invited, thereby also fulfilling the dissemination funding requirement. The group agreed with this strategy, and settled on local events in each school prior to the "big event" at the college, preliminarily scheduled just before the Easter holidays, a time the teachers deemed preferable to later in the last term, when there would be too many other non-negotiable commitments like school tours, sports days, Holy Communion preparations, etc. (Observation field notes, day five, August 1999 These discussions and Tomás's influential role in the decisions that were taken illustrates the importance of not only valuing the participants' experiences as the basis for learning but also having people from a diversity of backgrounds. This diversity not only increases the range of experiences and varying perspectives but also contributes to "enhancing their capacity to create things they really want to create" (Senge in O'Neill, 1995, p.20).

### *Stepping Back to Reflect*

Coincidently just as Tomás began to work with the computational materials in his classroom (April 1999), he had to complete a major written assignment for the ICT postgraduate diploma course. Being a person who was keen to follow his interests he saw this assignment as an opportunity to make sense of his EM workshop experiences and the questions that had begun to formulate as a result. "Stepping out" from the workshop experiences he would be taking "on the role of the eternal observer, or critic" and revisiting his experiences "as if" it were not his. He would "need to describe it to [himself] and to others, and in so doing...make it tangible" (Ackermann, 1996, p.28). He negotiated with the postgraduate course directors to base his major written assignment on investigating the background and theoretical underpinnings of the EM project. (Postgraduate assignment 1999, pp.2,5,6 - e.g., Vico, Dewey, Piaget, Papert, Resnick ).

Tomás believed that the "emphasis now being placed on the promotion of the use of information technology in schools" could provide "a new impetus and opportunity, to translate teachers' attitudinal acceptance of the principles of constructivism, into practical action in the classroom" (Postgraduate assignment 1999, p.4). He realised that "most forms of educational technology are designed for children to act as users" (Postgraduate assignment 1999, p.6). But the computational materials the EM project intended to use in classrooms "were 'designed for designers' so that children could use them to work through problems and to develop their own ideas" (Martin, 1996 cited in Postgraduate assignment 1999, p.6). This reversed the more usual pattern, which had children controlling worlds in the computer, and instead put them in a position to control computers in the world (Resnik et al., 1996 cited in Postgraduate assignment 1999, p.6). The programmable brick Tomás noted was "capable of interacting with the physical world of the children enabling them to become designers and inventors...involved in a new range of design and experimental activities that was not possible until now" (Postgraduate assignment, 1999, p.6). So the reason for introducing these computational materials into his classroom was "not merely to make interesting robots that perform complex actions or exhibit *'behaviours*" (Postgraduate assignment, 1999, p.6), as:

> the real power of these activities lies in changing how children think about computers and how they react to them, and in enabling children to develop new ways of thinking. In this way *'things that think'* become *'things to think with'* (Postgraduate assignment 1999, p.7).

Understanding the epistemological foundations and development of the computational materials he was introducing into his classroom may have heightened Tomás's commitment to the constructionist philosophy. He believes that "knowledge is becoming increasingly provisional" and it is in "this climate of change the most important skill to be learned is the ability to learn, and the ability to know how to react to situations we have never prepared for, nor even foreseen" (Postgraduate assignment 1999, p.10). Consequently his decision to become actively involved with the EM project was because he believed that it had potential for developing new ways of learning : "it is in its scope for developing new ways of learning and new ways of looking at learning that this project has the greatest potential" (Postgraduate assignment 1999, p.10).

This reflective process enabled Tomás to examine what underlying epistemologies were explicit or implicit in the policies and practices thatwere pursued (Sugrue et al. 2001, p13) in schools. He began to understand that every educational system and instructional program contains a theory of learning although this theoretical foundation usually is implicit (Shuell, 2001 p.10). Standing back from the immediacy of his classroom he was able to construct a bird's eye view of "the big picture perspective on the purposes and practices of schooling" (Warren-Little, 1993, p.139). This helped him, contextualise his involvement in the EM group and put his decision to use the computational materials into perspective. He began to see where each piece fitted together which in turn strengthened his understanding of and commitment to the constructionist principles underlying the EM project.

## *Tomás Back at School*

### *Enlightening Parents*

In the face of parental doubt about the value of their children working with the computational materials in the classroom, Tomás was vitally interested in providing parents with concrete examples of the Empowering Minds project in action. He got his first opportunity in January 2000, when the NCTE asked whether any of the schools involved in [funded by?] the SIP initiative would be willing to participate in the Young Scientist Exhibition in Dublin. Tomás was the first to volunteer, and he invited all the parents to make the trip with their children to this prestigious event—a very big occasion indeed, for these children from a two-teacher, rural school, whose parents might have looked askance, but whose doubts were partially allayed by national funding from the NCTE and third-level institutional support from St. Patrick's College, Dublin City University.

With scheduling very tight, a couple of parents volunteered to help build and paint scenarios for the models, such as the Maze in which Theseus and the Minotaur would do battle.

These parents were so fascinated by the project that they volunteered to help even after YSE, their first task being to redesign and reconstruct the rail around the top of the maze, which had broken under the weight of the many excited and interested spectators who watched Theseus use a light sensor to follow a black line into the middle of the maze, where he met and fought with the Minotaur (See Figure 58).

*Figure 58:* Young Visitors Watch Theseus Find His Way into the Centre of the Maze to Fight the Minotaur at the Young Scientist Exhibition (Dublin, 2000)

Building on this, Tomás followed up the YSE adventure with a open-school evening (March 2000) for parents and anyone else in the community who cared to come. To create a sense of occasion, Tomás not only held the event at the local education centre, he also organised a video conference among the project director, the children, and himself with Fred Martin at MIT's Media Lab, and invited postgraduate students from the outreach technology-in-education course (NUI, Maynooth) to participate too. He also invited the Director of the NCTE/SIP Initiative, and local teachers from first- and second-level schools. All present had the opportunity to query directly one of the actual developers of the computational materials. Orchestrating such a high-profile event served to demonstrate to the parents the interest that other educators from a broad range of backgrounds had, in the work their children were engaging with in their small two teacher rural school. This external validation was a revelation for the parents, strengthening their parents' belief and confidence in the use of the computational materials and the new approach to learning.

> When the parents saw the children interacting with others . . . and saw the reaction of the H.Dip students and the other teachers . . . it was like outside validation of what we were talking about to them. . . . They could see that people came from a great distance and people knew what they were talking about, and they were very enthusiastic about it and about the level that the children had got to. I think their attitude changed, as well. They could see a value in it that maybe they hadn't seen before (Interview, June 2000, p. 14).

In addition to valuing the learning process, the parents took new, real pride in their children and what they were capable of learning. Tomás reports that "One of the kids came in and said that when she went home, her mother shook hands with her and said, 'I'm just so *proud* of you!'" (Interview, June 2000, p.14).

*Figure 59: Female Student Demonstrating Springfield Project to Younger Students and Their Teachers—YSE 2003*

Tomás and his students continued to build his parental support base for the changed approach to learning by continuing to participate in demonstration events such as Learning Conference/Dublin Castle, 2000; Extreme Interfaces at MLE, February 2000 (See Figure 60); and in now-annual features of the school calendar, such as the Young Scientist Exhibition in January (See Figure 59), and the "Big Event" at St. Patrick's in June:

> Parents began to see how children were benefiting from it. They began to see that children were doing things that they didn't think it was possible for them to do and speaking a language that they didn't understand. The children were able to present their work and knew what they were doing. The work they were doing was being valued outside the school in other areas as well. Some of them had been convinced from the start but most of the others in fact all of the others have come around… they now see the work that is going on and they see the value it (Interview July 2003, p.4).

Frequent visits from the project director and interested educationalists, both Irish and from abroad, also validated for the parents the regard that others had for the quality and value of the learning environment these two teachers generated and continue to sustain in their tiny rural school.

*Figure 60:* Children Demonstrating Their Project at "Extreme Interfaces" Open Day, Media Lab Europe, February 2002

### *Classroom Practice and Changing Relationships*

Prior to his involvement with Empowering Minds, Tomás "found it hard to structure projects" and generally "would have gone away from [them]," as he had "found that project work is the kind of thing that just drifts on and on with no conclusion to it, and it expands to fill whatever amount of time that's available to do the thing. And that becomes frustrating" (Interview, June 2003, p. 5). The children had no clear understanding of what was meant by "do a project" either, so what they produced was the result of them "just . . . parroting stuff from other sources" (Interview, July 2003, p.5).

Actually, Tomás had been doubtful about project-based learning in general, based on experience and on what others would think of the noise level:

> I've always liked the idea of learning by doing, but at the same time, when you see a large group of children active in the classroom and the noise level is raised and the movement level is raised, you always have this doubt in the back of your mind—"Is anything really going on here?" I've always had that kind of suspicion (Interview, June 2000, p.12).

In fact, Tomás hadn't seen much to suggest that anything *was* going on:

> Before, if I gave them a project . . . they'd sort of operate in Squirrel Mode: collect everything, and then put it all away and forget about it. At

> the end of it all, they'd still be hungry, just like the squirrels. They'd know nothing, but they'd have it all stored (Interview, June 200, p. 13).

But in the immersive Constructionist learning environment of Empowering Minds, Tomás is far more convinced and confident about group learning. He "got to relate to children in different ways"—not as parrots or squirrels, but "in ways that I wouldn't have been able to do before" (Interview, June 2003, p. 6). And "Having seen the results of this, I would be much more likely, I think, to go in that direction" (Interview, June 2000, p. 12).

When he returned to his classroom after the first EM workshop (Easter, 1999), he adopted the Atelier-style workshop approach, and over time, he noticed that he was devolving more control of the learning process to the children.

> I was giving children more freedom to do their own thing, ..., I wouldn't direct them as closely as I would have done...and I'd be more likely to accept what they would come up with rather than saying yeah, that's alright, but...(Interview June 2000, pp.12-13).

In response, to this shift in control and Tomás's more respectful attitude to their ideas and contributions, the children were taking more responsibility for their learning, and beginning to think more for themselves: "They were more likely ... to define goals for themselves, than they would have been previously [and were] more likely to be maybe more critical of what they do" (Interview June 2000, p.13). And not just with the computational materials—their new self-sufficiency "had spin-over effects in all the curricular areas" (Interview, June 2000, p. 1). Tomás attributes this "spin-over" to the thematic approach. Narrative, for instance, "was a big thing in the project . . . because they were involved in story-making/story-building as well as building models . . . and integrating the work of different groups" (Interview, 2003, p. 6). And they learnt character along with design:

> The children got used to designing their own work, laying out projects for themselves and following them to completion and being able to report them back. They got used to having things go wrong as well as putting something right or making a decision to abandon it because [they] couldn't put it right or [they] had to change what [their] ideas were. . . . This gave them a new ownership of projects and a new independence, which they carried over into other areas (Interview, 2003, p. 5).

Tomás's students also began "working in groups of different ages and different class groupingos" (Interview, 2003, p. 6). Tomás noticed they had developed "a different attitude to working independently" as "they were able to work in groups without disputes." Tomás realised that "it wasn't just that I had a different attitude—so did they. He began to trust the children's ability to become self-determining learners "because they were now showing that they could be trusted" (Interview, 2003, p. 6). Tomás's attitude shift is consistent with Guskey's finding (1996) that when a teacher can attribute growth in students' learning to changes in classroom practice, the teacher's belief system changes.

### *Redefining Values*

As Tomás and his students worked together in the powerful new learning environment, the children themselves began to look different to their teacher:

> I would now see different qualities, skills and abilities that pupils had that we wouldn't have seen otherwise. . . . Many of the abilities that they had developed or maybe just had and were seen for the first time would have been ones that wouldn't have commanded a great respect in the classroom up to then. But now because they were shown to be able to do something that nobody else could do well, that had a currency of its own. Whether that was programming or building Lego or recording the things that had gone wrong, or the things that worked and having it available the next time it was needed. Whatever the skill was, they were valued for it (Interview 2003, pp.6-7).

Because his classroom practice is real, immediate, relevant and personally meaningful (Rogers, 1969), by using his classroom experiences as an "object to think with" (Papert, 1980), Tomás's own learning became embedded in his very routines of practice (Sugrue et al., 2001, p.8), leading him to concretise and verbalise his new understandings about learning in general, and about his students in particular.

Within his classroom there was a reappraisal of abilities and skills that were valued. Strikingly, he saw "the biggest improvement" in children who "wouldn't have necessarily have been at the top of the academic ladder, . . . the ones who would traditionally be good at everything. . . . In fact, quite often it wasn't" (Interview, June 2000, p.7). These children, many of whom attended "learning support and would have been quite weak in academic areas . . . turned out to be very valuable members of the groups . . . for the particular things they were able to do" (Interview, July 2003, p.8). These children developed "in self-esteem and their attitude to school and their general ideas about themselves or how they felt about themselves" (Interview June 2000, p.7). Tomás does not talk in vague generalities when discussing these claims but refers to specific children to illustrate how his value shift has affected them:

*The Recorder.*

Tomás often refers to this example of how one child's record-keeping skill led to his peers' reappraisal of his status within the group:

> When they tried something and it failed, and then they needed to go back to where they were beforehand to start again, and none of them could remember the way it was before it didn't work, whatever way the model had been built or geared, they'd find that this chap would have taken notes and he'd be able to say, "On such and such a day, this is what it looked like," or "This is what it was, and we have a photograph of it," and "We wrote this down." And eventually they realised that they could come back to him and he'd usually come up trumps. So from being the kind of fella who would have had very little to contribute to groups which were involved in "academic-type projects," he became an essential member, and when they were picking groups he was one they would want to have in their group (Interview July 2003, p.8).

*The Problem-Solver.*

A child who had been performing very poorly in school, and was being monitored by the school psychological service, demonstrated a dramatic change in engagement with learning: "[He] went for external assessment, and we had a review after a year. Part of the report from this review, that there had been a marked change in that aspect of work" (Interview, June 2000, p.7).

Tomás is referring here to this child's attitude to school and general self-esteem as he no longer was inclined to say, "'I can't do that,' or 'I don't want to do this,' or 'I'm not included in something else,' or 'I know by the look of it I wouldn't be able to do it'—that kind of thing" (Interview, June 2000, p.7).

This child became the person most consulted when various groups ran into difficulties constructing their models. Over time, Tomás saw this child's symbiotic enhanced confidence and his successful engagement with solving various problems.

> [H]e started to get involved in reading about it and presenting stuff. He needed to be able to spell, he needed to be able to read, and he had motivation . . . to do things that he wouldn't have been motivated to do otherwise. His whole academic performance improved dramatically, actually. Then he had the confidence he was not just building stuff, but he was presenting it. He went to lots of exhibitions and things where the kids would demonstrate and explain what they were doing to other people who, in many incidences, would have had very little knowledge of it, even though they might have been academics in their own right in other areas. So that the experience of presenting these projects and being able to answer questions on it, other people valuing the work that he did and the

> knowledge that he had was a great boost to his confidence[See Figure 61]. It reflected in a renewed interest in the whole academic area (Interview 2003, p.9).

*Figure 61:* Newly-Confident Child Explains Project at MLE High-Profile Exhibition

### ***Redefining the Teacher's Role***

Now more convinced than ever of the value of allowing adequate time and freedom for learners to formulate learning goals and make their own decisions and mistakes, Tomás was comfortable standing back and letting the children grapple with their own decisions even if they did explore what he previously might have thought "a very roundabout way of getting somewhere" or perhaps even a "dead end" (Conversation during classroom visit, March 2000).

*Being true to yourself.*

> Sometimes, certain beliefs that you have and the constraints that are put on you by your curriculum and other things mean that you can't realize your goals. You have an idea and you can never get even close to it and you're sort of producing educational results that you don't really believe in yourself, but others do (Interview June 2000, p.10).

Engaging fully in the immersive learning environment, and feeling supported within the EM group, Tomás was able finally to put into practice his suppressed beliefs about learning—a development entirely consistent with McLaughlin and Talbert, who maintained that "participation in a professional community . . . supports the risk-taking and struggle entailed in transforming practice" (1993, p.15).

*Shifting control by making time.*

In early visits to his classroom (March 1999; August 1999), I saw for myself that Tomás was not dictating the learning process or directing how things were to be done. He was allowing the children time and space to make their own decisions and mistakes (Field notes form classroom visits, September – December 1999). A simple example:

When the children began taking pictures of their models in construction, they wanted to store their photos—a simple procedure initially, as there weren't many, so any child could just check them all to find the one they wanted to show someone or use in a story. But when they had more photos, the children had to decide how to organise the photographs so that each person or group could find their particular photographs easily. They decided on a simple folder system that worked until someone changed the setting on the camera, so they had problems with filenames, and with transferring the files from the disk to their own folders on the computer. Tomás explains,

> When they put the next lot of photographs into the folder, they discovered they had the same names, the second lot had the same name—now they're in trouble! So they had to name the files. . . . But the name they put on it didn't make sense. So when they did find it, they had to go back and rename it with something that would make sense. Then, they forgot to put in the .jpeg at the end, so then they had to learn the significance of the file extension (Interview, June 2000, pp. 2-3).

Observing all this activity, and remembering his own experience of personally relevant learning (See Appendix E: Building the "Slow Vehicle"), Tomás did not interfere or explain the necessity of using appropriate names. He believed an opportunity would arise that would bring home to them in a more personal and meaningful way the purpose of the naming process (Field notes from conversation during school visit, October 1999). By allowing enough time for this process to evolve naturally, Tomás demonstrated that he understood the need for children to construct their own understandings and appreciated the benefits of contextualised learning: "They're learning an awful lot of stuff incidentally and using it straight away, that if you were to teach it in isolation would take forever and they still wouldn't understand the applications of it" (Interview June 2000, p.3). He saw the viral spreading of ideas as the children engaged in more peer learning, and often saw this spontaneous collaboration lead to new ideas: "I didn't have to go off and construct . . . lessons to show them how to do it. One person in the group showed the others and they learned off those, and then while doing it, they used and discovered new skills that none of them had learned" on their own (Interview June 2000, p.2).

He persisted with this way of working in spite of criticism when others might have considered it an inefficient use of this resource because they believed the children would have moved on more quickly and covered more ground (Conversation during classroom visit, February 2000). Tomás believes ample time allowed the children to naturally develop and evolve sophisticated problem-solving and debugging skills of their own. For instance, when a model did not behave as its builders expected it to, the children reacted differently over time.

> In the beginning, they'd invariably . . . assume it was the more complicated thing that had gone wrong, . . . usually the programming. Then, in the end, they began to learn to look for the simple thing. Go around first before you get into trying to solve the more complex end, which might not be it at all. You might be fixing things that might not be broken in the first place (Interview, June 2000, pp.3-4).

Occasionally, Tomás might discuss alternatives or prompt them to consider other possibilities, but he did not impose his viewpoint. The children considered his suggestions and gave them the same weight as input from the rest of the group.

They also had time to develop their own management and organisational procedures because their learning was now more contexualised: rather than learning in a disembodied, decontexualised way, the learner's needs and interests were driving the learning process. In the past, Tomás often had found himself "teaching them how to do something and [then] trying . . . to find an exercise where they can practice it. . . or trying to invent a use for it. [I was] doing the things the reverse way around" (Interview, June 2000, p.1).

But with the computational materials and enough time, things were "the other way around":

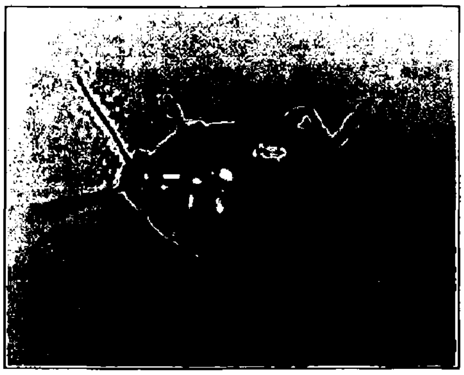
> There was something that they needed to do, they wanted to do, but in order to do it, they had to learn the skill, so once they learned the skill, they automatically put it into use . . . like riding a bicycle. You don't sit down and learn the skills of riding a bicycle and then see if you can go off and ride a bicycle, because a bicycle is standing there in the yard, usually, and you want to learn to ride it. . . . [O]nce [you] learn to ride it, the next problem is where [you] need to go on the bicycle, where it'll take [you], [you] don't keep concentrating on the skills! (Interview, June 2000, p.1)

For example, although the children originally got a digital camera specifically to record their models under construction, a visit to the classroom by a naturalist lead to a new use for the camera.: "Wildlife World came in with stuffed mounted animals and birds and so on, and immediately somebody said, 'Can we photograph all those with the digital camera so we'll have them the next time we go to nature projects?' We did and they made a folder of that" (Interview, June 2000, p.18). What formerly had perhaps seemed disconnected topics bearing no relevance to the children began to take on a new significance as the children realised that it connected with their own everyday lives and they could be involved. They had not just acquired the technical skills they saw it as a new form of expression. They continually found new ways of using the digital camera as a means of "making meaning" and understanding the world around them that would not have been possible without the digital technology. The children began to realise that they could personalise their learning and create their own resources for investigations they were interested in.

Now more deeply interested in nature, the children began bringing the camera home to take pictures of the trees and hedgerows in their locality. They compared the different types and discussed why particular species/varieties were suitable in different locations. They documented changes over time and stored their dated photos for later comparison (Classroom visit notes, October 1999/March 2000).

The children also became enthralled with mini-beasts and used the digital camera to record their observations rather than relying on reference books. They learned a lot by overcoming challenges and problems: lighting conditions, best times / places to record particular insects, how to entice particular creatures above the surface , etc. In order to project larger images (especially of smaller insects who had a habit of running off before the children could get a clear shot), they came up with a particularly clever innovation involving a jam-jar and a microscope (See Figure 62) one of the children had received as a birthday present (Classroom visit observation notes, November 1999).

*Figure 62:* Nature Diary Entry Using Microscope and a Jam-Jar



The children also used the digital camera to record significant events in their day-to-day school lives—for instance, they kept a pictorial record/diary of the new school building as it was constructed (Jan – June 2000). Tomás bought floppy disks for everyone to use in the camera. In this way, each child could record what they regarded as important to them.

### *The Emergence of Distributed Learning*

Rather than control of the learning process resting with the teacher the children began to take an active role in defining and setting the learning agenda as Tomás "let them run with their ideas" (Conversation classroom visit, April 2001). In the beginning he was sceptical and thought a lot of the children's ideas "seemed fanciful" and wouldn't work. But now, while the children are working on their projects, Tomás is "hovering around making suggestions or listening to theirs" (Interview 2003, p.11). When some group is experiencing difficulties and he thinks it appropriate, he initiates a discussion with them, using gently probing questions.

> If it won't do this, why won't it? What is it, what exactly is the nature of the part that we're not managing to succeed with and then what would you have to change to make it do that or given the materials or the programming that's available to you is it possible to do that at all? Or does what you're trying to do need to be modified? (Interview 2003, p.11).

He doesn't pretend to have all the answers. Recognising the children's expertise, he sees himself as a co-learner who works with and alongside his students: "I wouldn't have any more expertise than several of them in the class, at this stage," he says. "Some of them have been working with the materials now for more than 4 years. They know nearly as much as I do about it—more, in some cases. . . . When it comes to building or programming, some of them certainly know more than I do" (Interview 2003, p.11). The teacher has become more of a co-learner with learning being "more a cooperative thing" as a more equitable relationship exists between the children and the teacher. The children now set their own learning goals in consultation with Tomás: "I'd suggest something, and they'd suggest something. But it wouldn't be done just because I suggested it, or it wouldn't be totally theirs. What I suggested might be done—or it might not" (Interview 2003, p.8).

Tomás wasn't the only one in this new learning environment who was aware of the children's new skills and abilities: "The other pupils recognised them as well," and the classroom dynamics changed as a result (Interview 2003, p.7). When they needed help, the children no longer asked only Tomás; they began to consult each other, valuing each other's abilities and spontaneously generating peer-to-peer learning and support. The old "hierarchy of who knows more than someone else" was replaced by "the need for everyone to contribute." Everyone in Tomás's classes was "questioning, investigating and seeking solutions" (Kleine-Kracht, 1993, p.393).

Tomás acknowledges that in addition to the changes in his role of teacher, the computational materials were also responsible for enabling the learners to push on the boundaries of their learning. Unlike other materials, these computational materials were adaptable and provided feedback to the learner: "Even if it didn't work, they got some results, and they . . . [could] find out why it didn't work, and go back and either adapt their idea to something that will work or make it work" (Interview, June 2000, p.4).

Before Empowering Minds, this kind of learning would not have happened in Tomás's classroom. "There wouldn't have been occasion for it to happen," Tomás points out (Interview 2003, p.8). Prior to the EM project, the children "would have had a certain amount" of control but certainly not as much as they developed from their involvement with the EM project.

> The way it is in a small school, kids probably tend to have more independence or more ownership of the classroom anyway than they would in a large single class. . . . But certainly not as much as they have now. They design the projects and then they carry them out, rather than I do them (Interview 2003, p.7).

### *"A Certain Uncertainty": Pursuing Deep Projects and Developing a Learning Culture*

Of all the EM teachers, only Tomás has worked with a group of children who have continuously used the materials since the beginning of the EM project. Also, only Tomás has worked continously with children of mixed age groupings spanning multiple grade levels—the determining factor in both of these conditions being his position in a small, rural, two-teacher school.

At the end of the first year (Easter 2000), Tomás hoped he would be able to "take up the next year where [I] left off" so that he and the children could work on longer projects. His only concern was that the children continue to develop, that they would not get fed up with the computational materials and see them as a mundane activity (Observation notes Easter 2000). He was worried that

> the whole sense of adventure might go out of it as the second and third year rolled on and it might become routine and the value that the children got out of all the discovery might not be possible to repeat... which might be a bigger problem in our school than in the others because the same children would be using the materials ... even if we were doing it for a third or a fourth year, ...so, what I'd hope ...for a certain uncertainty so that as the year went on there would be a certain discovery (Interview June 2000 p.19).

Much to his delight, though, "there has been development over the years, and projects have changed but the essential story-telling element has remained" (Interview 2003, p.10). Tomás feels the thematic approach encourages development of collaboration with a corresponding interdependence of groups: "Groups were working with each other rather than against each other, in cooperation rather than competition" (Interview 2003, p.7). This cooperative approach, which Tomás singles out as being "a continuous thread and one of the best features of the project", was made possible because of the narrative thematic approach:

> The story-telling theme allows different groups to pursue different things and then come together bringing various aspects of the project together. . . . If one group's thing doesn't work, . . . and it all does not come together in the end, then the work that each group has done separately is devalued. So it's in every group's interest to make sure that every other group's part of the story works. So they help each other out rather than competing. (Interview 2003, p.10).

### *Dominance and Collaboration*

Because collaboration was important to this new learning culture, Tomás initially insisted (September 1999) that each group had to be gender-balanced. But it soon became evident that the girls were not being given a chance to participate in the development of the models. That year's gender ratio was atypically boy-heavy (3:1), so at the girls' request, Tomás let them form their own group (Classroom visit observation notes October 1999). Since then, his classes naturally have been more evenly balanced as to gender.

But this experience alerted Tomás to the folly of over controlling the groups' composition. He realised gender balance was not absolutely necessary in this new learning environment. As to age, Tomás revised the specification to allowed the children to select their own groups—

> but with certain conditions: . . . I would never have allowed four from , say, a third class, and [another] group of four from sixth class. I would have made sure that there was a mixture, but given that there might have to be one from sixth or one from fourth or one from third. Outside of those constraints, they could pick their own (Interview, June 2000 p.8).

Even so, a few children continually dominated, calling the project "'my this,' and 'my that,' and 'my project'" (Interview June 2000 p.8). So Tomás gently intervened when necessary, to encourage greater collaboration and inclusiveness. For example, when a group were trying to debug a problem, he modelled inclusive strategies by asking each member of the group what they thought might be the problem or their opinion on a possible strategy for getting round the problem. Sometimes, he suggested changes for other group members to try out (Observation notes, November 1999). But when he went to work with another group, the dominant children soon took over again (Classroom visit, November 1999).

So he gently drew the dominant children's attention to how they were not allowing others to work with the materials, suggesting that they let others try out the building, and they could still make suggestions. He modelled behaviour that would encourage collaboration among group members—for instance, he'd praise the contribution or idea of another child, in an effort to draw the more dominant child's attention to the importance to listening to others' contributions and suggestions (Observation notes from classroom visits, November/ December 1999).

Gradually, the children began to talk more with each other and listen to suggestions made by others (Classroom visit, March 2000). Here again, time made all the difference:

> When the deadlines came . . . for exhibitions and things had to be done fast, the one person in the group couldn't physically get it all done anyway, so they had to hand over some responsibility to some of the others. Then, also, they began to see that some of the others had ideas that were just as good as their own.

Inter-group competition melted away as the groups also began collaborating with each other:

> In the beginning, groups tended to be competing with each other and if they got a new idea, they kind of guarded it like a trade secret. But as the year went on, if they got a new idea and if they knew that another group was looking at some sort of similar problem, they went to the other group, told them what they'd done, showed them how to do it and they sort of took pride in everybody's achievement, as well as their own (Interview, June 2000, p.8).

Their sense of competition, which perhaps had been feeding on a need to dominate, had now been replaced by a collaborative sense of pride and achievement. And Tomás was caught off guard because "I thought that the more we went into exhibition-type stuff, the more competitive it would become. But it didn't. I was surprised at that" (Interview, June 2000, pp.8-9).

On reflection, he realised that he and the children had very different perspectives on public events. In the beginning, Tomás felt "a lot of pressure" about exhibitions. In contrast, the children took them in their stride and "even the day before an exhibition, when things were rough . . . they didn't get excited at all" (Interview June 2000 p. 23). Tomás initially couldn't understand this relaxed attitude:

> I kept thinking, they must think that the next day is going to last for three weeks! Do they realize how long it's going to take to fix that? Do they realize that there are so many different things that have to be fixed before that actually works? . . . It didn't seem to bother them that much (Interview, June 2000 p. 23).

Tomás couldn't get over the fact that "they weren't even frustrated because it wasn't working. They were happy that it was going to work *sometime*" (Interview June 2000 p. 23). He admits that he "learned from the kids" because on reflection, he realised "we put [pressure] on ourselves," believing that our work as teachers is on display more than the children's work as students (Interview, June 2000, p. 22). So when deadlines drew near, he was frustrated with the children as they made last-minute adjustments to models that then ended up not working (Easter feedback session, April 2000). Later, he realised that top performance wasn't the point when their learning was so much deeper and more meaningful for their being in control and setting their own learning goals, even though "everything took more time than anticipated" (Interview June 2000 p. 20)—that, too, was part of their learning.

### *The Sky's the Limit*

Tomás need never have worried about his students losing interest in working with the computational materials. Nor did they play it safe " by "doing the same sort of things with [the materials] and breaking up models and rebuilding a new model which was basically the same and doing nothing else" (Interview 2003, p.12). Over four years, he realised that once the children had ownership and control of the learning process, they continually sought new horizons. He now firmly believes they will always keep pushing the limits:

> They're not likely to be driving the thing back in the same direction, the direction they've already come from. They always want to do new things, try out new materials or new programming or new ways of presenting their work, and so did we (Interview 2003, p.12).

That "so did we" is significant: the teachers stayed just as keen on working with the EM computational materials as their students did. At their school website the progressive complexity of the children's projects is clearly displayed. The narrative theme continues a mine of material (see Table 12, Projects Derived From Narrative Theme).

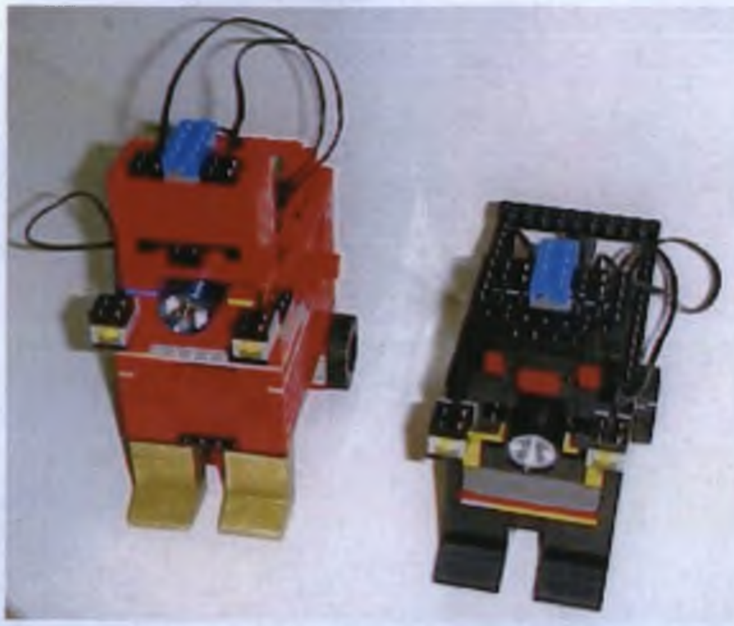
Table 12: *Projects derived from narrative theme*

| **Narrative theme** | **Projects developed** |
|---|---|
| **Local, national and international legends** | Theseus and the Minotaur (1999)<br>Táin Bó Cuailnge (1999)<br>Alice Kyteler (1999)<br>The Giant's Causeway (2000)<br>The Wooden Horse of Troy (2001) |
| **Investigations related to curriculum** | The Robotic Nature Quiz (2000)<br>Investigating mathematical concepts<br>- Speedo (2000)<br>- Ally the Adding Alligator (2000) |
| **Topical current affairs** | The U.S. Election Voting Machine (2001) |
| **Original stories developed by the children** | Earthquake in Springfield (2002)<br>The Break-in (2003) |

And each new project builds on the learning induced by the previous one: refinements learned from Theseus and the Minotaur clearly are evident in The Fighting Bulls of Táin Bo Cualinge (see Figure 63). The children have moved from using local, national and international legends to adapting stories from topical current affairs, culminating in the construction of original stories of their own. The Voting Machine

(See Figure 64), for example, was prompted by Florida's electronic-ballot debacle in the 2000 USA presidential election.

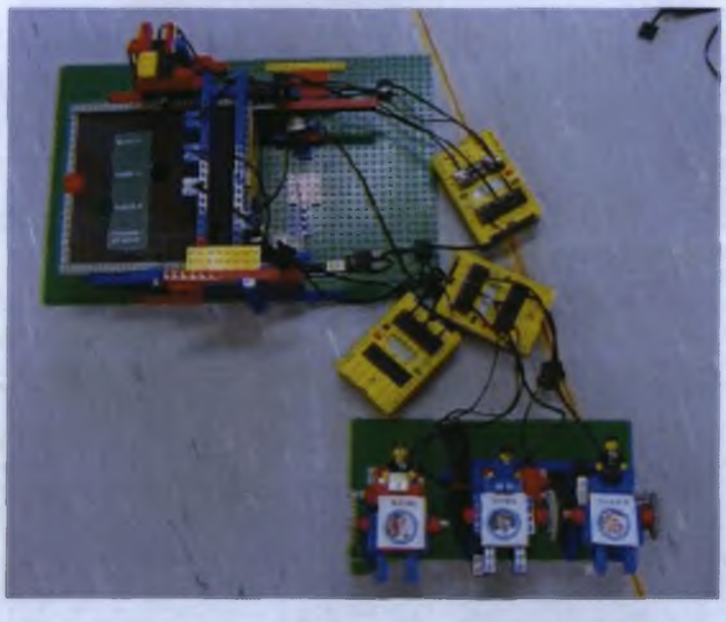
*Figure 63:* The Fighting Bulls of Táin Bó Cuailnge



Other early projects came from investigations sparked by curriculum, and developed into deeper, richer explorations of concepts and ideas than would have been possible without the computational materials. For example, while developing their aptly named model, "Speedo", the children explored the complex relationships among distance, speed and time. And in constructing "Ally, the Adding Alligator", they discovered that subtraction was the inverse of addition. (See Appendix F: Opening the Door to Formal Systems). With the development of the collaborative relationship with the National Centre for Sensor Research (http://www.dcu.ie/~ncsr/), they have used EM computational materials to extend their exploration of scientific concepts. Tomás and the children have field-tested new NCSR sensors and software, and have given feedback in aid the development of a data-logging software instrument. Tomás has also prepared a detailed outline of this work as a resource for the EM group.

In the last two school years (2002/2003), Tomás and the children have moved from smaller, discrete models to working all together on a single project theme in depth. Last school year's work was based around a single theme that grew out of a story the children wrote in the first term (September—December, 2002) for a short film they called *It Wasn't Me!* They wrote a script, made a story-board, made a set and cast the film. Then they filmed it and edited the film. They entered *It Wasn't Me!* in the Fresh Film Festival at the Belltable Arts Centre in Limerick, which attracted films from schools and youth groups all over Ireland, north and south. *It Wasn't Me!* was shown on March 28, 2003, and made the final competition, winning special praise from the judges for having been filmed and edited by the youngest group to reach the finals.

*Figure 64:* The Voting Machine inspired by Florida's electronic-ballot debacle in 2000 USA presidential election



The children then decided that they would like "to try to make Lego robots and programme them to act out part of the story" as their project for the YSE (January, 2003). They built and decorated the house. Then, when they got the robots working, they filmed them acting out the story, edited the film and put music to it. They called it *Who's In The House?*

As a result of their experiences at the YSE, the children decided to make yet another new film, this time with an emphasis on the construction and programming details of each of the models which they used to tell their story. The children believed this film would help answer the queries they had from the many interested adults and children at the Y.S.E. Shortly after they had finished this film, while they were deciding what project they would tackle next, the Mi Wadi cultural awards were launched (http://www.miwadi.com/cultural/default.htm). So the children decided to build on what they had done to date and develop a Mi Wadi project detailing the world—past, present and future—from the pupils' point of view: Mi Past, Mi Present and Mi Future. They did this project in the form of a digital video which the pupils shot and edited, using *Who's In The House?* as their idea of what life might be like in the future, when many things will be controlled by robots. They called it "Mi Future".

*Figure 65:* Investigations at Rathbeagh

For the Mi-Past portion of the project, they investigated a famous local historical site at Rathbeagh (See Figure 65 above). This investigation involved many local people—for example, an engineer who brought his equipment to the site and helped them take measurements using a Dumpy Level—as well as people from the "Irish History Live" group, who brought historical artefacts and period clothing for the children to dress up in. Tomás's students made a film documenting their work and the lives of the Celtic people thought to have populated Rathbeagh. And finally, for the Mi-Present section of the MiWadi project, they filmed some typical activities in the daily life of their school.

In September, no one had a year-long project in view, but it grew naturally when Tomás devolved control and the children worked collaboratively. With an extended repertoire of problem-solving strategies, increased technical fluency and an increasing ability to determine and manage their own learning goals, Tomás's students determined their own learning for a full school year.

"Earthquake in Springfield" and "Break-in" are other extended projects that developed in a classical bricoleur style, as evident by the reports written by Tomás and the children in the projects section of their school website:

> When we began planning what we would do for the Robo Show in June, we had quite a few discussions before any building began. After seeking ideas, the one that was eventually settled on was to make a kind of obstacle course and then each of four groups would design models to negotiate the obstacles. The initial idea was that we would quickly come up with a few ideas for obstacles, build them, and then each group could get on with the real task of building the vehicles to tackle the obstacles.
>
> However, as the discussion unfolded, pupils came up with many ideas for obstacles, and the obstacles began to take on a "life of their own." They wanted to incorporate light sensors and touch sensors, etc. into the obstacles, so that they could be activated by the vehicle, as it approached. They became so engrossed in the ideas for the obstacles that pretty soon the obstacles had taken on as much importance as the vehicles themselves. Eventually one pupil made the suggestion that, instead of having all four groups building vehicles, perhaps two groups should design the obstacles, and two groups design the vehicles (See Appendix H for full description of the development of this project).

Tomás found especially interesting the fact that the children were not content to build models using the computational materials in isolation but sought to embed their building and thinking within a narrative context (Conversation, group meeting, February 2002).

> Many of the ideas that came up were very interesting . . and so diverse. . . . Eventually it was agreed to have a single theme and that all obstacles would fit into that theme and this would help to tie the project together. . . . After much discussion the theme of a city hit by an earthquake was agreed. The obstacles would now fit in with events that might result from damage caused by an earthquake. As construction began we needed to locate the city and began to look for a name. Springfield, the hometown of the Simpsons, somehow became the chosen city. Now the nature of the obstacles began to take shape. There would be a bridge, which had been damaged by the earthquake. There would be a number of street junctions and the vehicles would have to select the correct route. But one question remained unanswered: "Where were these vehicles trying to go, and why?" We needed a story on which to hang whole project. More discussion.
>
> A story began to emerge. The earthquake had damaged the nuclear power station. There was some dangerous nuclear waste at the power station. For the safety of the city, it had to be transported to safety, and the trucks

> transporting it had to negotiate their way across the city. It was decided that the nuclear waste would be dumped into a disused mine at the other side of town (See Appendix H, How the project developed).

These later projects were characterised by complex interactive sequencing of events in order to tell a story. The models that the children constructed therefore did not stand alone but interacted with one another as elements of the story. This type of project development necessitated complex interactions, including close collaboration within and across all teams to decide on the storyline; the construction and functioning of each model; its interaction with the other models within the narrative context; complex programming of each model's functions and behaviours and the signalling necessary to trigger the next event; and an awareness of the consequences of change and its effect on the overall system.

Once in control of setting their own learning agenda, Tomás discovered that children are not content with mediocrity nor "would they make things easy for themselves" as "they set the bar pretty high" (Interview 2003, p.11).

> [N]ow . . . they try to design a project that will test their own abilities to build and to program and to put the thing together. So they are not happy to come up with something that they know will be easy to do. They want to put something up there and say "Can we do this?" And then "Let's see if we can do it!" (Interview 2003, p.10).

For example, with the Springfield project, when the children decided to design vehicles to overcome obstacles caused by an earthquake, they "had taken on a concept, which was to set problems for themselves and then to solve those problems" (See Appendix H). Sometimes his students may "have an exalted idea of what can be done" (Interview 2003, p.11). But Tomás does not interfere or try to change the goals they have set for themselves. He allows the children the freedom to set their learning goals and also acknowledges their responsibility for determining their own learning path. He has faith in the children's abilities and has learned that the children will adjust their goals as they see fit: "Once they start building, they realise the restrictions that are on them with the amount of materials available, or amount of time available, or space, or the restrictions of programming" (Interview 2003, p.11).

During the Springfield project, the children soon realised that "the imperatives of designing the vehicle forced changes to the obstacles, whereas on other occasions, the reverse was true." Bearing this in mind, the children made adjustments to accommodate the restrictions imposed by the materials, and the conditions imposed by the group responsible for the construction of the different models.

> They decided to set out at the start what maximum and minimum length/width/height the vehicles should be. After much discussion and measurement figures were agreed. Once construction began, these figures began to change as other considerations came into play. However, the principle that the models had to be built or re-designed with reference to the obstacles and vice-versa, was retained (See Appendix H).

When faced with a difficulty Tomás observed that unlike previously observed classroom incidents in other curriculum areas the children displayed incredible tenacity and perseverance when pursing a learning goal they had set themselves.

> If they built a model and it wouldn't work or wouldn't do what they wanted it to do they wouldn't automatically say "No, well we can't do that. Forget about it," they'd say, "Wait a minute! Can we make it do it?. Let's go back and see if we change this will it do it!" It would only be when they came to the conclusion that they couldn't actually do what they set out to do that they would modify what they set out to do (Interview 2003, p.11).

The children themselves detail many concrete examples of their tenacity and innovation in reports they wrote themselves, outlining in detail the problems they encountered with complex building or programming, and the solutions or workarounds they came up with (See Appendix H, Springfield Earthquake models; Appendix I, The Break-in—Description of Models).

### *Recording and Reflection*

Anticipating inevitable criticisms of some parents and school authorities and needing effectively to demonstrate the EM learning process, Tomás wanted some appropriate way to record the projects he and the children engaged in. Aware from research readings that the benefits of working in this way "are not so easily quantifiable and therefore, studies using only standardised tests are inherently biased in favour of formal methods" (Bennett, 1976, cited in postgraduate assignment, 1999, p.3), Tomás prepared display charts for the first open-school night (March 1999). These charts illustrated how the EM project is closely tied to the principles underpinning the Revised Primary Curriculum (DES 1999), and helped parents and other educators understand the EM type of learning better than they could have done just by looking at the finished product. Tomás has continued to develop these charts, and in answer to critics that he may be neglecting the curriculum, he has drawn up and posted on the school website a comprehensive comparison between the Revised Primary Curriculum and the EM project (See Appendix J).

Towards the end of the first year (1999-2000), he resolved to be more systematic and rigorous about effectively capturing and recording the learning process he was part of, and witness to: "Another thing, I think, . . . I would try to . . .have better recording of what they were doing. Several times during the year, they saw the need" (Interview June 2000 p.21).

Besides being conscious of recording the learning from his perspective, he was also mindful of trying to engage the children in the recording process. This, he believed, would serve as a means of reflecting on their learning experiences. Building on the Dreamweaver workshop in February 2001 (organised for the EM group in response to numerous teacher requests), Tomás has constructed a school website. He and the children regularly post detailed and comprehensive reports as they work with the computational materials to construct collectively interesting projects that have become more sophisticated over time as Tomás and the children have learned more. (See Appendices J and K for examples of project reports).

## Reflections: Teacher to Teacher

### The Importance of Being Part of a Group

Acutely aware that "one of the problems" of "a small rural school . . .is physical isolation," Tomás values the opportunities afforded by being part of the evolving EM community.

> Well, the overall group has been a very good experience for us because we've come across people with marvellous ideas and with great enthusiasm and with concerns as well. We shared concerns and shared enthusiasm and shared ideas, and every time we come together, somebody has a new idea or a new story to tell so that's been a big part of it for us. And we've made friends out of it as well (Interview 2003, pp. 11-12).

In the early days of the project's development, particularly when first using the computational materials with the children, Tomás highlights the "solace" he had from being part of a group with whom he could share experiences:

> [W]hen things were going wrong, you could be consoled with the fact that things were going wrong somewhere else. Or, at least, they were having the same problems. . . .Sometimes you'd see people with the same problems you have, or have worse, or better. Or they have solutions, or

> they have different ones, and you can say, "Thank God I don't have *that* problem!" So that's interesting. Then, there's the fact that you would get together and you could talk about something and pool ideas and pool your sorrows as well.

Tomás found the group meetings and discussions, which stimulated the flow and exchange of ideas, simultaneously inspiring and humbling experiences

> When we met, we'd get ideas. Sometimes, you'd tend to think that you don't have any ideas yourself and other times you think nobody else has ones as good as yours. Both of those myths exploded every time you'd meet the group (Interview, June 2000, 2000 June p.16).

He believes that the diversity of the group has been an important factor in increasing the opportunities for the evolution of new ideas (Louis & Kruse, 1995).

> The other members of the group ... are a motley crew. They come from very different backgrounds ...with very different experiences and everybody has something different to bring to the group and to the project and we've shared ideas (Interview July 2003, p.12).

A culture of sharing has developed, which Tomás believes has ensured the continuous development of the EM project: "The project hasn't stood still. It's developing all the time. . . .It's changing all the time, and every time we meet, someone has come up with a new idea somewhere" (Interview 2003, p.12).

### *Expansion Tensions: Fostering Group Participation*

As one of two teachers in a small, rural school, Tomás was particularly sensitive to a lack of communication across EM classrooms:

> Once we go back into our own classroom, you're locked into what you're doing yourself...you get suddenly isolated from what's going on in the other schools... So there needs to be a sort of a link, some sort of overall unity about the thing (Interview, June 2000, p.26).

So he posited that "with the best will in the world, although we talked at length about making connection with other teachers and children, we had to do something structured" (Workshop notes, April 2000). Perhaps because he was comfortable with using digital technology for communication he thought that digital tools could form the basis for communication across the group: "I thought as the year went on that ... we might develop through E-mail and perhaps a Web site ... more of a learning community" (Interview June 2000 p.16). On reflection he realised that "time" and "experience" (Huberman, 1995) were probably behind this lag in development of online communication. Others in the group had all they could handle already, just trying to cope with the existing computational materials, which is consistent with Knowles' argument that adults "become ready to learn those things they need to know and be able to do in order to cope effectively with real-life situations" (Knowles, 1998, p.67). It was going to require a cultural shift in values for EM teachers to reach out to others. In addition, people required a strong community of acceptance and trust (Zetlin et. al. 1998; Mc Laughlin and Talbert, 1993) to feel safe doing this (Maslow, 1972).

Tomás recalled his experience of trying to foster communication between his own school and schools in Greece, Sweden and Austria as part of the Comenius project. He had previously assumed this European group had communication difficulties because they did not all have English as a first language. Seeing the EM group have similar problems, though, he began to wonder whether "maybe we were skirting around another problem. Maybe there was another underlying problem that language was only exacerbating. Time might be a big thing" (Interview June 2000 p.17).

### *Making Connections—Anticipating Problems*

Though he was pleased that additional EM funding became available in April 2000, Tomás suspected the communications problem was going to be exacerbated if the project expanded. He pointed out at the feedback session after the project exhibition at St Patrick's College (April 2000) that the project director was the only person who had an overall picture of developments at each school gained by regular visits. If the number of schools increased, the number of visits per school would drop, and the focus would naturally be on visiting the new schools. Keeping updated on developments in other classrooms and feeling a part of a community with shared values and goals would become increasingly difficult particularly if the communication relied exclusively on face to face group meetings or visits from the project director (Notes from feedback and evaluation workshop April 2000).

The other EM teachers attributed the lack of communication to their having been consumed by the challenge of working with the new computational materials, along with anxieties about parental attitudes and curriculum requirements. The ensuing discussion did not come up with any suggestions beyond using email to ask for help with a problem.

True to his nature, rather than waiting for difficulties to arise, Tomás tried to think through the problem. He wondered if the expansion would "change the relationships among the schools" (Interview, June 2000, p.24) or if the first group of teachers perhaps could act as support to the new teachers. He was sensitive to the new types of relationships that might spring up among new EM teachers. He felt ownership and was willing to take responsibility for EM's further development:

### *Learning as a Participatory Social Process*

Tomás now more clearly understands learning as a participatory social process. Collaboration rather than competitive ideas are valued.

> Everybody's ideas are valued in the project and everyone's concerns, I think, are addressed, and there's a good atmosphere of sharing. I'd never get the sense that schools are trying to be one-up on the other school, so that any new ideas are shared straightaway. And if you're stuck with something, you can always throw out a question, either by email or by phone or when we meet, and there'll always be some suggestions coming back, and encouragement as well (Interview 2003, p.13).

This dynamic development and evolution of ideas has kept Tomás's interest kindled in remaining an active member of the EM community: "We're doing things now that we'd never envisaged at the beginning we'd be doing, so there's no reason to think that it won't continue to develop in the future" (Interview 2003, p.12).

Equally important has been the fact that although the project developed in many directions in response to the group's needs and interests, he did not feel compelled in any way ((Sugrue et al., 2001, p.39; Grossman & Wineburg, 2001) to pursue any line of inquiry if it was not directly related to his own needs or interests: "[I]t might be one that we'll run with, and it might not. But there's always been developments since we started the project, and [it's] still developing" (Interview 2003, p.12).

This sense of remaining in control is significant for Tomás's continued involvement with the group.

### *From the Outside, Looking In*

The rationale for developing a community is that they can support and sustain teacher learning (McLaughlin and Talbert, 1999; Cochran Smith and Lytle, 1999, Nelson and Hammerman, 1996). For Tomás, the EM project helps counter the myopia which can develop as a result of the isolationist nature of the small rural school context:

> Sometimes, particularly in our type of setting, where you're in a small school,you can be working away in your own little environment and each school can be kind of a little republic,and you may never get the chance to sort of stand back and see yourself as others see you and see what you are doing as others see it. (Interview 2003, p.13)

Besides helping him develop multiple perspectives about his classroom practice, the supportive structures and diverse composition of the group means that "you have access to the research that the whole project is based on" (Interview 2003, p.13). His own research highlighted for him the inconsistencies in teachers' beliefs based on theoretical perspectives and the reality of their classroom practice. He wanted to avoid these inconsistencies in his own classroom practice because to do so "means . . . that we're not just flying by wire. That a lot of thought has gone into it and that research continues to go into the project and that it's well grounded in academic theory as well as practice. (Interview 2003, p.13)

### *The Outsider's Perspective and Validation*

Besides being a very important source of collegial support, Tomás sees equally important functions for members of the group in "supportive evaluation" and "validation." He refers in particular to visits to his school by members of the group (Fred Martin and me) who are not practising teachers but are engaged in academic learning research:

> It's important that people from outside will come to the school, look at what you're doing, discuss what you're doing and set it in . . . an academic context. . . . It's reassurance that the work that you're doing is not just enjoyable, . . . it's valid, and . . . valued from outside. . . .It's a supportive type of evaluation of what you're doing in a way and it's another forum to discuss what you'd like to do or what you are doing or the problems that you're having (Interview 2003, p.13).

Extending the membership of professional communities beyond classrooms and school campuses had demonstrated that this could be a powerful form of teacher learning (Darling-Hammond & Mc Laughlin, 1995; Wood 1995). This type of support was "a big issue" for Tomás because as he had indicated he was "nervous about the whole idea from the beginning" (Interview 2003, p.14). But having someone "come in from outside, and look at what they were doing, and talk to them about it, and get involved with it", (Interview 2000 p.24-25) was very important for Tomás. Particularly isolated in his small, rural school, he believes support from outside is a necessity.

> You need to have encouragement from outside that what you're doing is efficacious and is the right thing to be doing. And if you don't get support, eventually the doubts will set in, and I suppose when you're in doubt you'll eventually go back to what's tried and tested. Or maybe tried and not tested! (Interview 2003, p.14)

With this last comment Tomás reminds us that perhaps some practices in schools, are not founded on sound epistemological principles. So we need to examine critically our beliefs and assumptions in order to understand what learning is and from there design and develop effective learning environments.

## *In Conclusion*

In his small, rural school, Tomás has built and cultivated a thriving example of a Constructionist learning community. Starting with 3 PCs, Tomás and the children now have access to a network of 8 PC's with Internet connectivity, an Apple iMac (extensively used for video editing) and a laptop (primarily used by Tomás outside of school hours and for off-site demos). They also have a range of other computational devices, including an extensive collection of the Mindstorms materials, a digital stills camera, a digital microscope, a data projector and a digital video camera. During the current school year they have also begun experimenting with the "Cricket."(See http://llk.media.mit.edu/projects/cricket/about/index.shtml and http://www.handyboard.com/cricket/). Using this broad range of computational materials, Tomás and the children engage in deep personally meaningful projects. Their personal needs and interests provide motivation, direction and focus to these projects. As teacher, Tomás now understands his role to be that of a co-learner with his students. He respectfully works alongside them and is comfortable devolving control and ownership of the learning process to them. He is content that his classroom practice now reflects his true epistemological principles.

Though some may say it is only to be expected that Tomás developed over time, as he was positively disposed to using digital technology and had an underlying belief in Constructionist learning principles, it was (as Tomás constantly reminds us) the support of the EM group that enabled him to take the risk and develop his Constructionist classroom practice—and to continue to do so. A range of studies (Zetlin et al., 1998; McLaughlin & Talbert, 1993) demonstrated that participation within a supportive community that encourages sharing and dialogue promotes the trust and the risk-taking necessary to support the struggle entailed in transforming practice. The EM community also helped break down the barriers of personal and professional isolation that he so keenly felt, consistent with Rosenholtz's (1989) findings that teachers who felt supported in their own ongoing learning and classroom practice were more committed and effective than those who felt isolated and unsupported. Tomás also highlights the culture of encouraging ownership and devolving control to the learner that exists within the EM project as significant factors in his development as a self-determined learner.

### *The Role of Support in Changing and Developing Beliefs*

The literature points to a need for expert support at the level of the school that can demonstrate, coach, observe and provide constructive feedback, facilitate networks of learners, etc. (Huberman, 1995; Warren-Little, 1993; Joyce & Showers, 1996). Because he knows how hard it is to swim against the tide, Tomás believes that the support and validation he received within the EM community kept him from backsliding into the comfort zone of traditional teacher expectation. He acknowledges that "you mightn't feel comfortable with it, but you'll follow the line of least resistance eventually" (Interview 2003, p.14). From personal experience he believes outsides forces, particularly parental pressure, can wear down a teacher's ideals. Without support and external validation it is difficult to stay motivated when one's beliefs are stultified by external expectations and are not actualised in one's own classroom practice.

During his study for his B.Ed degree, Tomás discovered that there wasn't always direct a direct link between beliefs and actual classroom practice:

> A lot of teachers believed in the principles of . . . Constructionist education and Constructionist learning, but even though they believed it, the work that they were doing in the classroom didn't demonstrate that belief. And I'd say that would have been as true of me as anyone else (Interview 2003, p.13).a

Although they "believed at one level," these teachers—including Tomás—had attributed their inability to work in a Constructionist environment to"all sorts of classroom constraints, the curriculum and financial constraints" (Interview 2003, p.13/14). However, being convinced of underlying principles does not necessarily equal competence in translating these principles into practice (Bolhuis, 2000). In light of his experiences with the EM project, Tomás acknowledges that the key to designing a Constructionist learning environment in the classroom lies in the hands of the teacher who is supported to take the risk.

> There was the other constraint: that *we weren't prepared to take the chance* . . . but this project enabled me, anyway, to do that—after some initial nervousness—and I think most of the teachers on the project would say the same, that maybe for the first time in our teaching career we are doing the kind of teaching that we have always claimed to believe in—probably did believe in, but we were a bit nervous about getting immersed in (Interview 2003, p.14).

Tomás could take the risk because he was supported by the EM group:

> I'd consider it important that just as we had an input into how the project was going to be run in our school and how we were going to set it up ourselves, that other teachers coming to the project fresh now would feel that their own ideas were valued and that it wouldn't be handed down to them in prescription form—"This is what we did, therefore this is what you should do". That we would only say "This is what we did" in the sense that we developed it this way from our own ideas—"Now you go and develop following your own ideas." The other thing that's important is that there would be support for teachers who might be keen to get involved but are like we were in the beginning, nervous of the consequences for other subject areas or for the attitude of management or parents or whoever might be putting pressure on them to follow a certain line. That their fears or anxieties would be allayed to some extent by . . . some support structure . . . for them (Interview 2003, p. 15/16).

Tomás highlights this ownership and control as the most important principles to consider when expanding the EM community to include other teachers. However, he is very aware that this support from within a community cannot be assumed to exist and must be carefully and systematically cultivated (Sugrue et al., 2001,p.40). It requires an investment in personnel and the development of a framework of supportive structures that are responsive to the needs of the learning community in order that more teachers can teach the way they may have always known they could, if only they had the opportunity.

# Chapter Six
# IMPLICATIONS OF CONSTRUCTIONIST TEACHER LEARNING

My study demonstrates how urgently we need to acknowledge and confront the epistemological foundations of our present learning principles. I articulate and explore their implications both for teacher learning and for the ways digital technologies are conceptualised and used by learners. Developing a model of teacher learning informed by Constructionist principles, this study demonstrates an effective alternative to current practices of teacher professional development, particularly in the use of digital technologies. This study demonstrates how teachers' uses of technology both in immersive Constructionist workshops, and later as they worked alongside their students, allowed them to redefine their own understandings of learning. They engaged with their personal epistemologies and were challenged to change their ways of working with children in the classroom.

In this dissertation, I identified and elaborated key principles underlying the development of this powerful learning environment concerned with challenging perceptions of learning which impacts on subsequent classroom practices and student learning. Using a select number of case studies, I provided concrete examples of Constructionism in action that begins to address the question of what being digital can mean in learning. Finally, I extrapolated a set of conditions necessary to support teachers in becoming self-determined learners and 'critical' judges of digital technologies, in order to determine what being digital can mean in learning. This has the potential to change educational strategies on personal, community and national scales.

In this chapter, I review the principles of Constructionism and the implications for the way learning and teachers' roles are conceptualised, elucidate the conclusions to which my research has led me, and offer my recommendations towards implementing the necessary changes this study indicates.

## *Confronting and Changing the Epistemological Foundations of Our Learning Principles*

Acknowledging the principles of Constructionism from the outset had implications for the design of the learning environment and the role of the learner. This study demonstrates how these understandings of knowledge and learning directly influenced the ways teacher professional development is conceptualised.

Constructionism implies that learners will be actively constructing new knowledge, rather than having information "poured" into their heads; Constructionists argue that people learn with particular effectiveness when they are engaged in constructing personally meaningful artefacts. These artefacts become "objects to think with" and a means by which others can become involved in the thinking process. Constructing an artefact implies that some materials and tools are used. It makes sense that these should reflect the tools currently valued in a culture. In our current climate, digital technologies naturally would feature prominently.

However, these tools should not be limited to those only valued within any one particular community or sector of society. A wide range of challenging and expressive computational materials should be considered. This artefact they comprise becomes personally meaningful as the learner engages with its structural and functional properties and works with fundamental ideas such as control, feedback and variability. These basic aspects combine with the particular expression, which is the learner's constructed object or artefact, to create a learning experience that is uniquely, personally meaningful and memorable. Without this personal meaning, Tucker and Batchelder (2002) claim that the developmental cycles that facilitate conceptual change rarely develop. Csikszentmihalyi (1997, cited in Willis and Tucker, 2001, p.5) in his research on creativity found that when we like what we do and are motivated by it, focusing the mind becomes effortless even when the objective difficulties are great. So the learners' needs, interests and experiences are at the forefront of the learning experience. The computational materials used should be capable of reflecting and deepening both these interests and experiences while enabling, through the construction process, deeper understandings of computational ideas and processes. Learners, in turn, must accept responsibility for setting their own learning goals in order to meet their interests and needs.

Involving others in the thinking process implies that the process of constructing this artefact is shared. Learning, therefore, is understood as a social participatory process (Vygotsky, 1978; Lave and Wenger, 1991). Csikszentmihalyi (1997) maintains that sharing completes the human experience of creativity. Papert (1980, 1991a, 1993) also placed a strong emphasis on creating what Cannings and Stager (2003) call "shareable" (Cannings and Stager, 2003, p.2) objects that can be shown, discussed, probed, critiqued and admired. The group dynamic is important as the artefact grows and learners share and reflect. The emergent design of a learning environment consistent with these principles implies that control and ownership of the learning process is vested in the learner—and every person in the environment is a learner.

This type of learning environment involves a sea change for teachers, as they themselves become Constructionist learners. They begin to work alongside their students, collaboratively learning with them and modelling good learning strategies. They become able to articulate how they think and learn and reflect on the learning in their classrooms. They transcend the barriers of traditional classrooms and work collaboratively with others on deep, meaningful projects and problems. They form a supportive collaborative community of learning professionals who are continuously learning and thinking about learning. Ultimately, they will contribute as this community extends.

In addition to the development of the EM community there have been other research projects which have focused on teacher professional development informed by constructivist or constructionist principles and the effective use of technology. However these projects differed significantly from the EM community's development in a number of ways that may be significant including:

- Subject specific (e.g., Confrey et al., 2002 – maths and science; Lesh, 2003 – maths)
- Short duration (e.g. 16 week multi-tiered program design project, Schoor and Koellner-Clark, 2002)
- Focused at pre-service level only and in a single course (Willis and Tucker, 2001)
- Focused exclusively on student learning (Xiaodong et al., 1996; Confrey et al., 2002)

A conference at Balcones Spring described by Confrey et al. (2002) highlights key features of other constructivist projects that allow comparison with the present EM project. These projects (See Table 13 below) had a decade of experience in creating researcher-schools partnerships in order to promote a systemic approach to student learning, teacher professional development, standards-based curricula, meaningful assessment, and effective use of technology.

Table 13: *Examples of Long-term Science and Mathematics Research Projects*

| Project | Research Organization | Urban Sites | Participants | Years in operation |
|---|---|---|---|---|
| LeTUS | NWU<br>Uni. Michigan | Chicago IL<br>Detroit MI | 62 schools | 9 |
| http://www.letus.org/ | | | | |
| SYRCE | Uni. Texas | Austin TX | 6 schools | 4 |
| http://syrce.org/ | | | | |
| Schools for Thought | Vanderbilt | Nashville TN | 125 schools | 6 |
| http://peabody.vanderbilt.edu/projects/funded/sft/general/sfthome.html | | | | |
| Union City Online | EDC | Union City NJ School District | 11 schools | 6 |
| http://www2.edc.org/CCT/cctweb/project/descrip.asp?2 | | | | |

(adapted from Confrey et al., 2002, p.3)

The projects outlined above shared characteristics with the EM community, some of which are listed below:

- Trajectory / Approach dimension
    - Emphasis on student learning
    - Work with students and teachers in and out of classrooms
    - Iterative design and refinement process
    - Focus on sustainability and on increasing the capacity of the system
- Structure dimension
    - Emphasis on empowerment and engagement of practitioner-collaborators as opposed to provision of outreach or technical assistance
    - Shared expectation of hard work
    - A long term shared commitment with an extended timeframe for achieving results.

(adapted from Confrey et al., 2002, p.4)

In common with the EM community they also found the following to be among the key elements successful in professional development for teachers:

- A respect for teachers as professionals. Professional development should be collaborative and the knowledge and experience of teachers and other participants should be respected; professional development is an aid to growth, not an imposition of what other believe is best practice
- A model of professional development as a community of practice with diverse distributed expertise; Distributed expertise through collaboration implies that roles are re-defined and that a breakdown of traditional roles can be expected. This in turn must be supported with organizational accommodation, where

school and district level policies and procedures are responsive and change as needed, rather than being imposed as fixed constraints

- A model that helps all participants to see professional development as based on mutual self-interest, respect, and trust; and an alignment of interests. Sufficient time and reorganization of work-load structures must be undertaken in order to make participation in mutual professional development a regular part of the work of researchers, administrators, and teachers. (Confrey et al., 2002, p.7)

As with the EM community they believed that "all must be committed to ongoing learning, to critical re-examination of their current practices, to learning from one another and from peers" (Confrey et al. 2003, p.6). The "all" they refer to however includes teachers, researchers and administrators and does not include the students or others (e.g., computer scientists, engineers, film-makers, and parents) whom we in the EM community consider to be equally important and significant participants within our learning community.

However the projects differed from the EM community in that they focused exclusively on the maths and sciences content areas and were specifically focused on student learning and achievement. This focus on student achievement and the emphasis on conceptual subject specific knowledge rather than an understanding and awareness of a teacher's epistemological foundations, which are informing their classroom practices meant the development of very different professional development programmes. The programmes within the projects outlined above were "all to the end of providing the kinds of teaching and educational environments needed for students to learn to higher standards of achievement" (Confrey et al. 2003, p.6), as related to standards based curricula. The belief was "if teachers are to provide better instruction for all students, what they learn about teaching must be related to understanding the conceptual content of the subject areas they teach" (Confrey et al. 2003, p.7). But does conceptually understanding the subject content better necessarily change a teacher's classroom practice? Indeed as Schorr and Koellner-Clark (2002) have indicated even "when teachers adopt specific changes or strategies (like using manipulatives) into their classroom practice, they often do so within the framework of their older (more traditional) models for teaching and learning" (Schorr and Koellner-Clark, 2002, p.6). Schorr and Firestone (2001) also confirm that although teachers are willing to adopt a new strategy, tactic or procedure they generally speaking do so without changing their overall perspectives about the teaching and learning process.

The EM community's focus, on the other hand, was on the development of self-determined learners, pupils and teachers. So, rather than starting from a specific set of givens in the form of standards based curricula, the EM's immersive Constructionist learning environment rich in computationally expressive materials and not bounded by subject barriers, challenged teachers to question their own epistemological assumptions and beliefs leading them to redefine their own understandings of learning. Within the EM community the teachers have become co-learners with their students. There has been a radical change in relationship for as the teachers embraced EM's constructionist principles a "mutual doorway" has opened. "The barriers between adult and child and between teacher and student are broken and it's person to person. Nobody is looking down at anyone, they are looking at each other right in the eye" (Foresteer cited in Buckle, 1990, p.63).

There was another major departure from the principles underlying the EM community and the projects referred to above. This was, "the inclusion, *when possible*, of analysis and assessment of student learning and of student work in the professional development activities" (italics added, Confrey et al. 2003, p.7). Within the EM community, on the other hand, reflection on their student's learning was at the very heart of the EM teachers' professional development activities. Their workshop experiences and all subsequent professional development activities were closely tied to their classroom contexts. Anchoring the teachers' own learning with the digital technologies, in their everyday reality of the classroom allowed teachers to use their own teaching practice as 'an object-to-think-with' (in the Constructionist Papertian sense). Their own learning consequently was closely linked to the children's learning in their classrooms and it was the changes and developments that they witnessed in the classroom which concretised the learning process for the teachers. So the teachers' classroom experiences became the richest source of learning, their object to think with, and the lens through which they began to reflect upon and question what they understood as learning and their own role as teachers. At the same time, these experiences encouraged them to continue with the project. This study demonstrates that as the teachers worked with and alongside their students, they began to externalise and examine their understandings of learning, and experiment with and ultimately transform their teaching practice, their relationships with their students and their understandings of their role as teachers.

This Constructionist approach has far-reaching implications for the way learning and teachers' roles are conceptualised within our educational institutions. The work described in this dissertation, and in particular the individual case studies, demonstrate that teachers' traditional beliefs and assumptions can be challenged in ways that lead to significant changes in their understandings about learning and their subsequent classroom practice. EM teachers have become self-determined learners capable of identifying and setting their own learning goals. Initially, with my support, they felt able to take risks, tolerate uncertainty, and engage in reflective questioning. Over time, their self-esteem increased and their confidence levels heightened so that the needs for my support decreased as they became increasingly able to take risks and ask questions on their own. Engaging with the EM process, these teachers found themselves able to question their epistemological foundations and transform their understanding of knowledge into an entity constructed by learners in a social participatory process, rather than as a fixed, transmissible entity. They changed their classroom practices and reconceptualised their roles as co-learners and facilitators, to the degree that they can also devolve control of the learning process to the child, just as the EM project did with them.

## *Key Principles for the Emergence of This Fundamentally Different Learning Environment for Teachers*

By allowing sufficient time and developing appropriate supportive environments, this study demonstrates that teachers can construct new understandings of what learning is. Key principles that emerge for the development of this learning environment, concerned with challenging and supporting teachers' perceptions about learning and their subsequent classroom practices, are:

- Immersion: With computational materials, in an Atelier-style learning environment and among an extended community of reflective practitioners, which challenged and empowered teachers to learn about learning.
- Sustainability: As teachers were supported in their appropriation of the computational materials and ideas, and in their thinking about thinking, we developed a range of supportive measures to ensure that once they began this reflective process of thinking about thinking, the process could continue beyond the workshops, thus empowering the teachers to become self-determined learners.
- Scalability: To prevent good ideas from disappearing, we focused on finding ways to encourage and promote spreading the ideas and widening the community.

### *Immersion*

People make assumptions when introducing digital technologies into schools. Many think that it is just a question of "fit" and thus focus on integration and teacher training. In contrast—but consistent with Vygotskian thinking—this study claims that changes in tools prompt changes in thinking, radically altering views of learning and potentially changing the world. When we see computational materials as a context for questioning existing values and beliefs about learning—not simply as tools to fit the existing system, or as remedies in and of themselves—we move from technocentric to epistemological thinking, asking how computational materials and their manners and situations of use can challenge existing practices within classrooms.

We may legitimately ask whether these challenges to assumptions about learning would have been possible without the particular computational materials used in the EM study. I would argue that other technologies typically used for teacher training courses more easily promulgate existing values within schools, as they mostly emphasise collecting and communicating information—it is no coincidence that people use the term ICT (Information and Communication Technologies) when referring to digital technologies in educational contexts. As prevalently used, these technologies bolster the traditional transmissive mode of education. In contrast, by using computational materials as constructive media, we promote development of learners' own understandings through expressive engagement with underlying powerful ideas such as feedback and variability, thus enabling a different understanding of knowledge and learning as a participatory social process rather than purely as transmitted instruction, as in traditional approaches.

Digital technologies enable different forms of expression and meaning making empowering individuals to move closer to full self- actualisation (Maslow, 1972). I agree with Papert's observation that "until recently the narrowness of range of the possible doings severely restricted the implementation of the idea. The educational vocation of the new technology is to remove these restrictions" and enable "a restructuring of knowledge itself" (Papert, 1991, p.22). Now we can pursue a Constructionist learning approach and design a learning environment that is Constructionist in nature. Learners have at their disposal digital technologies that afford them access to powerful ideas in ways never before thought possible. Through situating these materials in Atelier-style workshops, this study demonstrates the feasibility of designing an immersive Constructionist learning experience. The EM approach successfully encouraged the emergence of "dialogue, self-expression, community and reflection" (Ueda, 1999). This experience extends through reflective exchanges among the overall EM community and ultimately challenges individual teachers' existing beliefs and assumptions about learning.

### *Sustainability*

The EM teachers began using new technologies and challenging their assumptions about learning initially at workshops. Then they faced the challenge of re-situating their learning within the classroom and needed particular supports in order to do so. Research on teacher development over the last two decades had indicated that changing teachers' practice is enormously complex; no single prescription fits all schools and teaching-learning situations, as context is crucial to the quality of teaching and learning; key variables in the process of change are interactive and dynamic rather than linear, sequential and predictable; and school leaders and teachers are central to the process (Sugrue et al., 2001, p13).

I was puzzled by policy makers' evident continued determination to ignore these findings by developing generic inservice programmes that grant teachers no significant ownership or control over their own learning. Policy makers continue to endorse decontexualised, one-size-fits-all programmes that bear no relevance to teachers' own needs and interest. Yet they staunchly expect to see swift changes in the system. They seem to have lost sight of the fact that schools are fundamentally made up of people. As Hall & Hord (1987) emphasise, organisations do not change—individuals do. Fullan (1993) points to the importance of the people being at the centre of the change process. He stresses that the individual provides the most effective route for accomplishing systemic change as individuals change systems, acting separately and together.

I believed we could sustain the reflective questioning about digital learning initiated at the immersive workshops only if we found some way to connect workshop activities to the daily reality of these teachers. We had to embed this questioning in a context that would continue to be meaningful to them. Teachers' understandings of learning are rooted in their classroom practice, so naturally, we anchored their learning to their everyday reality. Teacher professional development could then be understood as a learning process that takes cognisance of the personal, social, historical and physical contexts of the teacher as learner. This approach recognises teacher learning as an ongoing process, placing the teacher firmly at the centre. Their "lifeworlds" rather than their "systemsworlds" (Habermas, 1987) became the generative force, enabling their own learning to be anchored to the everyday reality of the classroom with their teaching practice becoming their 'object to think with'.

### *Contextualised Support Framework*

Each EM teacher's context was different, so they required a unique set of supports. Because no single prescription could apply to every teaching and learning situation, our support design had to be flexible and appropriate in order to be sustainable. In stark contrast to other teacher development programmes that generally do not support teachers when they return to their classrooms, the support we constructed emerged in direct, swift response to the ongoing expressed needs and interests of the teachers that arose out of their classroom experiences with their students. Our development process was interactive and dynamic rather than sequential, linear or predicable. As the teachers began to receive our actions on their suggestions, they felt more confident to articulate their needs. By responding directly to their requests, we also built an ethos of trust. Among our support structures, we included the partnering teacher within the school, the workshop format of building activity followed by reflective discussions, group meetings, my visits and other teachers' visits to their classrooms, cluster groups, and the specially-developed web platform (http://empoweringminds.mle.ie ). This framework sustained EM focus on the value of classroom experiences, enabling the teachers to continue collaborating, reflecting and critically evaluating their own learning and what was happening within their classrooms.

As the case studies illustrated, when they began appropriating the computational materials and the Constructionist principles in their classrooms, the teachers were reluctant to seek help from group members and relied heavily on my visits to their classrooms for input as they progressed. Over time, as they learned to trust each other and became more comfortable with the computational materials, they started to ask each other for help. By willingly turning to others for help, they made a significant step in their development, as most teacher believe that they must be completely self reliant. If a teacher were seen seeking advice, then it was generally assumed that the teacher was ineffective or incompetent. Initially face-to-face meetings facilitated this interaction among group members; later, some teachers who were very comfortable with the technology made very limited us of email among themselves. The teachers identified lack of infrastructure as a barrier to their collaboration across the EM group, but with the installation of wireless technology in the classrooms, connectivity was easy, and the teachers increased their use of email as a means of support. Also, with input from teachers, we designed and constructed a web-based platform (http://empoweringminds.me.ie ) to facilitate this exchange of experiences, which enabled all members of the EM group to share resources and project developments, advise on current problematic issues, etc (See Butler et al. 2002). The EM group gradually is building up its unique identity and developing a common culture centred on learning about learning.

This "knowledge of practice" (Cochran-Smith & Lytle, 1999) placed each teacher at the centre of their own problematic practice, which developed over time with others in a learning community as a result of reflective inquiry. The range of EM supports also ameliorated the generally accepted tendency that "teaching, more than many other occupations, is practised in isolation, an isolation that is at times crushing in its separateness" (Maeroff, 1988, p.3).

EM's supportive framework and its cultivation of a learning community where ideas are discussed and understandings enriched were critical to the design of this effective learning environment. By allowing ample time, offering a range of support structures, and emphasising an ethos of trust and acceptance across the emergent learning community, this study substantively acknowledged how hard and personally threatening teachers find breaking out of the transmissive culture and traditional role expectations they have grown accustomed to.

### *Why Not "Whole-School" Focus?*

This study did not focus on whole-school development, which has been and still tends to be the predominant vehicle for change in the educational system. The whole-school development position is that support for change has to come from within the school. Within-school support is important; however, it should not imply that the entire school should be focused around the same initiative if that initiative is not universally meaningful or of common concern. I believe that the support of just one other teacher within the school can be sufficient to sustain motivation, provided that these teachers belong to a larger, supportive community. All the EM teachers have commented that on a day-to-day basis, they valued the support of the other EM teacher in the school. They stressed that just knowing they were part of a large group was important motivation for them. And belonging to a group who do not share the same context provided multiple valuable perspectives. Such a group provided a stronger source of challenge and a more flexible support mechanism than could be possible within a single school.

### Core Findings

EM's type of sustainability requires an investment in personnel, a comprehensive framework of support structures responsive to individual teacher contexts, and funding at individual teacher level, rather than whole-school focus.

#### *Investment in Personnel*

As project director, I visited the EM classrooms regularly—at least once a fortnight each, so I was able to work alongside the teachers, providing support to each individual at a time when, perhaps they felt most vulnerable (See Appendix E). As they began to use the materials with their students, they were risking exposure of the fact that they did not have all the answers. Like their students, they were just learning how these computational materials could be used. At that stage, encouragement and supportive feedback were critical to them in sustaining their involvement and continuing to think about learning.

These classroom visits also were chances to discuss the learning process and the problems they experienced, which gave rise to reflective thinking. The teachers regularly commented that having someone who listened and cared enough about what they were doing to visit their classroom was invaluable in buoying up their self-confidence and increasing their motivation to persist in confronting their own beliefs and assumptions about learning. Gradually, as teachers became more confident, they were able to take on more responsibility for their own learning. They began to lean more on each other for support and the group, rather than I, became the main source of support.

#### *Adequate and Appropriate Support Structures*

Individual teachers need support in ways that address their own needs, interests and experiences. As the EM group evolves, it may be able to continue this development of collaborative support structures using digital technologies because "increased communications is one of the biggest changes technology offers . . . to . . . transcend the walls of isolation" (O.T.A., 1995, p. 2). If this power of technology is harnessed and used in a collaborative environment, an effective learning community could be established across an ever-expanding community of learners as they continued to understand what being digital can mean in learning. Current problems of isolation would be reduced, the community of learners widened, and classroom walls, as they exist at present, broken down. The challenge will be to find the best way to facilitate and grow this collaboration and communication using digital technologies in a way that is meaningful, easy to use and unobtrusive.

But we should not assume that digital technologies can replace face-to-face contact, or that we can take short cuts to sustain this process of learning about learning. This study has demonstrated that initial support for teachers must be face-to-face. Even those teachers who had a higher level of technical fluency stressed the importance of this personal support framework.

The barriers to confronting one's own beliefs are difficult to break down. Digital learning is not just a matter of installing a technological infrastructure as a means of facilitating communication. Professional, societal and personal attitudes and perceptions of what learning is, and what a teacher's role should be, are difficult to transcend, and tend to persist even when new modes of communicating them become available. Before we deploy the technologies, we must address deep questions about learning and classroom practice, and teachers need to come to terms with their own learning beliefs and assumptions.

For future initiatives, when we build a culture of learning and developing communication across groups of teachers, we will have to be sure not to take any shortcuts in time or resources. We need to provide adequate time and resources. I was surprised by how long it took, even face-to-face, to build up the trust and confidence the group required in order to share classroom practices and ideas about learning. In the added complexity of a computer-supported collaborative environment, even more time and extra resources will be necessary.

### *Funding at Teacher Level*

If we are to encourage teacher learning, we need to provide adequate funding of appropriate support for teachers in their classrooms. Additionally, we need to fund substitute cover in order to release teachers for several days from their own classrooms in the first year, at least, as they begin this process of self-determination.

This study demonstrates that providing teacher release days to attend the cluster and whole group meetings, the review days, and some of the initial workshops, contributed enormously to the sustainability of the process of learning about learning. To the teachers, being released from normal classroom duties meant official recognition that time spent on their own learning was valued. Release support is not an indefinite commitment, as illustrated by events in the EM project. When release support was withdrawn upon the termination of the SIP initiative at the end of the second year of the EM project's development, I was worried that teachers might not continue to come to group meetings or workshops as these now had to take place outside of school hours. But despite the long distances that many had to travel, the teachers continue to meet as a group to plan future developments. These teachers have reached a point in their own development where they are ready and willing to pursue their own learning goals without needing the external motivation of release time.

Finally, to encourage the continued exploration of understanding of what digital technologies can mean in learning, we need to establish a multi-layered approach to the funding of teacher learning initiatives. We need to develop imaginative and innovative funding arrangements that will allow funding at the local level in order to combat the problem of centralised planning that, Papert claims, casts teachers "in the role of technicians whose job is to implement the plan" (Papert, 1991, p.21). With discretionary local funding, teachers could set their own professional development priorities without having them tied to some centrally advocated initiative. Otherwise, the individual teacher's initiative is hampered, and the system is deprived "of the flexibility to adapt to local situations" (Papert, 1991, p.21).

Local funding also recognises the centrality of allowing teachers to decide what they need to develop and learn and not what others have decided they must know. In this way, focused learning communities, not necessarily exclusively school-based, can receive funding and support across schools. The policymakers' big leap of faith will be to teacher-base, rather than school-base, the funding, so that teachers can make their own decisions rather than have them imposed by the principal at school level. This issue is critical in shifting the balance towards "teacher learning" because if others continue to determine teacher professional development, they will create a dependency culture among teachers, so much so that besides not having any control over their learning, teachers will have no ownership of any reform or change that is introduced, as others will determine their professional needs and then "minister" to them by "facilitators" and "experts" whom they cannot select. We urgently need a policy commitment that allows teachers "to identify their own needs and to determine how they will facilitate their own learning"(Sugrue et al., 2001, p.45). Such a policy strategy will encourage teachers to engage in the "self –directed search and struggle for *continuous learning* related to one's own expertise and standards of practice, rather than compliance with the enervating obligations of *endless change* demanded by others" (Hargreaves & Goodson 1996, p. 21).

### *Scalability*

Policymakers may feel the cost of the supportive structures outlined above is excessive. They are concerned with economies of scale and may be afraid that projects like the EM initiative, with its "costly" need for high personnel investment, cannot be sustained. However, in agreement with the sentiments expressed by John F. Kennedy, I believe "there are risks and costs to a program of action, but they are far less than the long-range risks and costs of comfortable inaction".

Designing and supporting initiatives like the EM project are initially expensive in terms of computational materials and personnel. However such initiatives should be considered in the broader time frame because they can initiate and sustain long-term change, as teachers become self-determined learners. It is a long-term investment but it is a lasting one. Encouraged and supported to pursue their own needs and interests, many of the teachers within the EM group have developed different areas of expertise. Learning about learning has resulted in a variety of digital technologies being explored in depth by different members of the EM group over the past five years (e.g., robotics, video editing, web authoring, networking and wireless connectivity). This expansion contributes to the rich diversity of the group and is evidence of the power of initiating the process of developing self-determined learners.

A number of these teachers are now confident enough and willing to assume the role of support that I initially provided as EM group director as is evident from the core group of 12 EM teachers who design and facilitate professional development workshops for other teachers based on EM principles and the appointment of one of the EM teachers as the co-ordinator of the new learning initiative in the Digital Hub (See Appendix L). These teachers can provide support as the EM group expands to include more teachers in other schools. In this way, the framework of support will be maintained as the community grows, with the more experienced learners acting as support and resource to the newer members of the group. If the initial conditions for learning are well established and grounded in the everyday reality of the classroom, then the teachers will develop and become self-determined learners. There will also be a viral spreading of ideas as a learning culture develops and the learning community expands.

Inspired by both the enthusiasm of their students and the response of the community, the EM teachers have developed a great strength of belief in the work they are engaged in. They have been invited to host workshops and present at conferences and exhibitions (See Appendix K).

In addition to these activities, the teachers and children have hosted visits to their classrooms from interested educators at home and abroad, including delegations from Czechoslovakia, France, Netherlands, Austria, Denmark, America and Japan. In addition to the research papers[17] published about the EM community's development, quite a number of newspaper articles[18] featuring the work of individual schools within the Empowering Minds Project have also been published e.g. *Irish Times, Dundalk Democrat, Kilkenny People.* A special 10-minute feature about the EM project in one of the inner-city disadvantaged schools was broadcast on national television as part of the "Dot What"[19] series of technology programmes. Children from some EM schools were also interviewed at the Young Scientist Exhibition about their extensive project work and featured on national television in the News2Day[20], a new daily news programme for children.

A number of other significant developments have arisen directly from the Empowering Minds project, including:

- Independent Teacher-Led Initiatives
- Extension of the NCTE's teacher development programme to include extended immersive workshops informed by Constructionist principles and the computational materials used by the EM community

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[17] Research papers related to the EM community:
Butler, Martin, and Gleason (2000).
Martin, Butler, and Gleason (2000).
Butler (2001).
Butler and Martin (2001).
Shepherd, Butler, Mikak and Diamond (2002).
Butler, Rasmussen and Davenport (2002).
Butler (2002).
Butler and Gash (2003).
Butler (2004).
[18] Newspaper articles
[19] Dot. What programme, broadcast on Network 2, May 2000
[20] Broadcast on Network 2 as part of Den 2, at 5p.m. on Thursday 23rd January 2003.

- The publication of advice sheets distributed to all schools on the computational materials and learning approach used by the EM community
- The Liberties Learning Initiative within the Digital Hub
- The TeachNet Ireland project teacher professional development programme
- The C2K Mindstorms Learning Initiative in Northern Ireland
- The European Primary Village professional development programme for teachers

These developments demonstrate the spread of Constructionist principles and the approach to teacher learning advocated by this work (See Appendix L).

## Recommendations

### Conditions Necessary for Constructionist Teacher Learning

The EM project and the developments outlined in Appendix L are based on a vision of teacher learning that is in stark contrast to the current models of teacher professional development. These models are generally controlled by outside agencies, such as centralised government, or regional or local educational authorities who decide on what inservice teachers need. "Experts" generally deliver the inservice in a one-size-fits-all package, rather like an inoculation, and without backup support for when the teachers try to implement the package in their own classroom. The system sometimes pays homage to individual school differences by giving planning time after delivery, to customise it for their own circumstances—a strategy which reminds me of Henry Ford's attitude to car sales: "You can have any colour you like as long as it's black."

Continuing Professional Development (CPD) for teachers, if approached from a Constructionist perspective, will result in shifting focus in three important ways:

- from teaching to learning, with implications for every aspect of classroom practice;
- from the current strategy of once-off/stand-alone inputs, to a continuous teacher growth and development process that increases and ultimately results in self determination; and finally,
- from the current top-down-imposed delivery model, to teacher-identified initiatives creating a new bottom-up model of emergent change.

This study demonstrates that it is possible to ask new questions and develop flexible responsive structures within institutions to support teacher learning, which in turn facilitates the development of new ways of learning in schools. The case studies outlined here provide insights into the development process of teachers as they grappled with understanding what digital technologies can mean in learning and began the process of becoming self-determined learners. While the findings of this study cannot be generalised to the entire body of teachers, I believe this study has illustrated certain conditions that have emerged and that need to be satisfied if we are to initiate and sustain this process of "learning about learning".

This study highlights the following conditions as necessary for teacher learning:

- Use of provocative, engaging, and challenging computational materials;
- Sustained, immersive, Constructionist Atelier-style learning environments that engage teachers in challenging learning experiences, informed by their own interests, needs and experiences and providing opportunities for teachers to experience problem-finding and self-direction for themselves;
- Embedding teachers' learning in their own practice and using this classroom practice as an object to think with, using their own practice for experimentation and trying out new ideas;
- A support framework that addresses each individual teacher's needs, interests and experiences;
- For discussion, criticism, and reflection, a supportive community with a diverse range of backgrounds particularly collaboration with a community of practitioners involved in similar work;
- Adequate time (a minimum of three years) to allow teacher self-directed learning to begin to develop and for changes to take place.

In this study, I have demonstrated that a culture of learning about learning can emerge when these conditions are satisfied. During the course of five years, ordinary teachers in the EM group have demonstrated what extraordinary learning environments can be designed and nurtured when teachers are empowered to become learners. The complex cultural context involved in the development of this generative culture of learning has included teachers, children, parents, interested educators, both national and international; school authorities; national agencies such as Ireland's Department of Education and Science (DES) and the National Centre for Technology in Education (NCTE); funding sources such as the NCTE, the Higher Education Authority (HEA) and *eircom,* the national telecommunications company; and educational institutions such as St. Patrick's College, Media Lab Europe (MLE), the Medialab at Massachusetts Institute of Technology (MIT), and the National Centre for Sensor Research (NCSR) at Dublin City University (DCU).

To understand how Ireland can make best use of the findings presented here, we need to revisit policy decisions that have informed current education structures, particularly uses of digital technologies and concordant preparation of teachers. These EM teachers are now well positioned to engage actively with "new priority project areas for funding" (DES 2001, p.13) that the government's "Blueprint for Action" plan intends to identify. The rationale for doing so, they argue, "will ensure that new methods of learning, teaching and research continue to evolve" (DES 2001, p.13). However, the standards or values that will inform the ways these new initiatives are to be prioritised is not apparent in the documentation. As we await the announcement of the third government policy document concerning the use of digital technologies in our schools, we worry because we still don't know which learning principles will inform these upcoming policy decisions.

Even when the philosophical underpinnings of some policy decisions are articulated, the same learning principles do not always inform the subsequent teacher development programmes designed to support the policy decision. Quite often, two very different paradigms are in operation. For example, it is ironic that primary teachers are expected to implement a curriculum based on Constructivist principles (DES 1999), yet they are not provided with a development programme that affords them the same Constructivist learning conditions they are expected to create for the children that they teach.

At the same time, teachers also are expected to appropriate digital technologies and integrate their use into this Constructivist-based curriculum. However, the inservice programmes designed to support teachers to implement the curriculum based on Constructivist principles make very little reference to using digital technologies. Somehow, teachers are to be trained in the use of these technologies without any acknowledgement of Constructivist principles or their own individual social, historical or physical contexts.

This denial of teachers' individual needs, interests and experiences looks likely to continue into the future. The findings of the National Policy Advisory and Development Committee's report (NPADC, 2001) for example, do not encourage or promote critical questioning of what being digital in learning can mean. The NPADC strongly recommend that the DES and the NCTE prepare a Strategic Action Plan to ensure "that methods of integrating ICT into the teaching and learning process and models of good practice are disseminated to the primary and post-primary system as a whole" (NPADC, 2001 p.10). The language in this statement implies a top-down initiative, which runs contrary to a Constructionist philosophy that would encourage each teacher to construct their own understandings of the appropriate use of these digital technologies in learning. Digital technologies are considered to be something extra to fit into the existing educational provision, and teachers are still to be trained in their use.

By adopting this conventional approach to using digital technologies within our educational system, we fuel fears of "curriculum overload" mindset and ignore the value of bringing together knowledge that traditional curricula artificially separate. This approach cultivates polarising viewpoints that can negatively impact perceptions about how technologies are used. Cuban observes that, in our rush to embrace technology, schools are neglecting important features of our culture:

> As public schools and higher education are being asked to build the human capital that many believe is essential to sustaining technological innovation and global competitiveness, . . .other historic and broader civic purposes [e.g., democratic equality] appear to be no more than distractions" (Cuban, 2001, p.10).

Rather than considering any element in isolation (i.e., digital technologies, teacher professional development, curriculum), this study considers the combination of factors informed by an overarching framework that addresses the issue of each individual's deep learning within a digital context. This places the "lifeworld" firmly at the centre as the generative force, ensuring that digital technologies are used to develop and enhance it and to maintain the balance with the "systemsworld" (Habermas, 1987). Consequently, this study looks beyond how teachers use technology to how teachers' uses of technologies, working alongside their students, allows them to redefine learning itself and become self-determined learners.

### Challenges to Teacher Educators and University Structures

Three years after the withdrawal of official release time from school, the EM teachers are still pursuing their own learning goals, which attests to the fact that these teachers have become self-determined learners. However, it is incumbent upon the university structures within this partnership to recognise this teacher learning and extend or adapt their forms in some way as an acknowledgment to these self-determined learners.

### *Developments at Postgraduate Level*

If we as educators truly subscribe to Constructionist principles, we have to change our conceptualisation and development of postgraduate programmes for teachers. Rather than design predetermined, generic courses with no input from the intended participant, we need university-level structures that enable teachers to determine their own learning paths. Just as this group of EM teachers were faced with redefining their role within the learning context, teacher educators must examine their roles in a context that promotes teachers as self-determined learners.

For example, at St. Patrick's College, we have begun to establish a structure for formally recognising the type of teacher learning engaged in by the EM teachers. A small number of faculty members within the Digital Learning team of the Education department have developed a flexible modular structure of postgraduate coursework that teachers can engage with. Course design is organic in that the content remains flexible and dependent upon teachers' needs, interests and experiences. All course work is rooted in the teachers' classroom practice. Rather than completing predetermined assignments, teachers design their own school-based projects that contextualise the course work they engage with. Using a variety of media, teachers also document their reflective thinking while constructing and working on these school-based projects with their students. Sharing is encouraged across the community, and it is supported by organising regular review sessions at a number of locations nominated by the teachers.

Within this structure, teachers can pursue a postgraduate diploma in Digital Learning that accumulates credits towards a Masters degree in Education, accredited by Dublin City University. To date, using this structure and an adaptation of it within the regular M.Ed programme, four EM teachers have completed Master's degrees, four EM teachers have begun the postgraduate diploma, and two more have committed to begin this diploma in the next academic year.

### *Developments at Undergraduate Level*

This reconceptualisation of an appropriate learning environment to encourage teachers to become self-determined learners should not be confined to practising teachers only. Preservice students need to experience alternative teaching and learning models and strategies as part of their own education (Willis and Tucker, 2001, p.4). Otherwise they will continue to teach the way they were taught (Wideen, Mayer-Smith and Moon, 1998). This will result in an isolation of the schools from a society where technology plays a vital everyday role (Willis and Tucker, 2001, p.4). We must give serious consideration to current teacher-preparation programmes. At St. Patrick's College, the Digital Learning team have begun to establish vital but often neglected institutional connections between preservice teacher preparation, and practicing teachers in the field. We have begun to create the bridge between preservice teacher preparation and practicing teachers with the development of a new course, called Digital Learning, for a small cohort of students. This elective course is part of the final year of the B.Ed. programme and constitutes 25% of a student's final grade for coursework in education. To date, two groups of students have engaged with this computationally rich Constructionist learning environment informed by the students' needs and interests. Working closely in classrooms with the teachers in the EM community, and having completed the Digital Learning course, these preservice teachers developed greater understanding of the theoretical principles underlying classroom practice. Over the course of the yearlong programme many of these preservice teachers began to challenge their assumptions and beliefs about learning and gradually became more aware of the importance of experience for building understandings. They dispelled the myth that the teacher had to know everything and began to realise that children are capable of setting their own learning goals.

As their coursework progressed, their confidence increased, and many of them were more adventurous in trying out new ideas, particularly during their Teaching Practice (using computational materials, designing active learning environments, group work, discussions, devolving more control to the students). These were important beginnings of self-determination and realisation of lifelong learning. Consistent with these developments those who initially had been apprehensive overcame their fears of using computational materials and developed a broader understanding of how computational materials could be used in learning. As they began to develop deeper understandings of the relationship between theory and classroom practice, they slowly broadened their conceptions of what a learning environment could be. The majority of these preservice teachers became comfortable with the concept of working with and learning alongside their students, and began to change their understandings of the teacher's role and the learning process.

These observations cannot be generalised until more in-depth research has been conducted in this area. However, these observations (See Appendix M) highlight our need to reconceptualise initial teacher education. These preservice teachers appear to bring with them a deep-rooted scepticism about the application of theory to classroom practice, and reluctance to try out what they hear in lectures.

> We never were in practical situations that we could really look at how people approach problems or how they went about learning. . . . [I]t was very theoretical, really. It's all grand in theory. . . . [V]ere many of the courses went against the student-centred approach to learning, . . . but this gave us practical experience. . . . When we were out in the schools, working with the LEGOs, people worked together and solved problems (BR, Interview, May 2002).

> You hear in college in a lot of the courses . . . that it should be all problem-solving and using different methods, but you don't actually see a lot of it. But with this [EM] really brings everything together. You can see things happening, and that it works, and that it's worthwhile doing. It actually brought everything together. Throughout the three years, everything seemed to be in different little subject areas. It's only actually now that everything seems to be coming together, especially philosophy. This elective brought it into context (C, Interview, May 2002).

However, once they experienced these ideas in action, these students were more prepared to try things out themselves and design more adventurous learning environments for their own students:

> Comparing my TPs [teaching practices], no matter what subject I was doing, I'd have them more active 'cos I saw that it wasn't as threatening. . . . [I]n a lecture, they'd be saying it was great and all that, but you'd be kinda going, "Look, I got through it this way, so I can get everyone else though it that way." But then when you saw it wasn't as threatening as you thought, you'd be more comfortable with it. So you were prepared to go out and try it, and you didn't mind doing it. . . . You wouldn't be afraid anymore to go out and give it a bash (AM, Interview, May 2002).

Therefore, these preservice teachers must experience a learning culture similar to that developed within the EM community. Working with the children and teachers of the EM community challenged their assumptions and beliefs about learning and initiated reflective questioning about what being digital in learning could be. Unlike the formalised teaching practice these preservice teachers usually participated in, their work with the EM community gave them a context for understanding the learning process rather than developing "teaching skills" that then were to be assessed in an artificial context.

> When I was out on Teaching Practice in September, I was concentrating on getting the lesson done, written up, and looking good for the inspector. You weren't concentrating on how the kids were learning. But when you

> were out in the classrooms with the lads in Ballymun [school in EM community], you could actually see them thinking things through. They were thinking out loud about what they were doing and how they were going to debug it, and you could see each step they were taking . . . now you can see what active learning is (AM, Interview, May 2002).

I hope these students will continue to be part of this community of practice as they commence their teaching careers. They fulfilled the university requirement for assessment in ways that was personally relevant and meaningful to them, as evidenced by their digital portfolios detailing their learning experiences over the course of the year. Now, as a new group of preservice teachers engages with this course each year, they will continue to evolve this unique learning environment and engage other faculty members to work with us. To date, in addition to the Digital Learning team, faculty from the assessment and evaluation area, as well as some members from science education, have worked with these preservice teachers in this new elective course. Applying the learning and design principles used in the development of the courses outlined above on a college wide scale could help us address the main conclusion of the report from the Working Group on Preservice Teacher Education which stated "that teacher education needs to be reconceptualised and programmes radically restructured" (Government of Ireland, 2002, p.154).

### *Faculty Development*

Along with this course development, we also have directed attention to raising awareness among the faculty members of St. Patrick's Education department in order to begin to address the question of what being digital can mean for learning. I organised a research seminar to share with faculty members the developments in the EM community and the work the Digital Learning team were doing in our elective courses. I also organised a number of workshops for interested faculty members to engage with a range of expressive computational materials.

The most successful of these was a two-day, off-campus immersive learning experience (September 2002), which was made possible through funding secured from a proposal to the HEA to support staff development in using digital technology. The 20 faculty members who engaged with this novel learning experience worked collaboratively with a range of computational materials to design and develop their own projects (See Figure 66). They combined this off-campus workshop with visits to the classrooms of some of the small rural schools and discussions with the teachers in the EM community. Like the teachers in the EM community, some faculty members admitted to being a little anxious in the beginning but commented afterwards that they never had laughed so much in their lives and yet learned so much.

*Figure 66:* Faculty Members Fully Immersed in Two-Day Workshop

Like the EM learners, these university faculty members were deeply immersed in their learning experiences as they worked on their projects. They skipped coffee breaks and lunch, and even stayed behind to work on their projects. During the reflective conversations, many of them began to see links between their own coursework and their learning experiences in this workshop. For example, one faculty member, who had been very apprehensive because of his own lack of technical fluency, was very excited and enthusiastic because he could now see the link between Dewey's principles of learning and his own experiences during the workshop. These experiences demonstrate how effective this learning is for faculty members and it is of the utmost importance that ample time is allowed for them to engage with this kind of immersive learning. As with the teachers in the EM community, this immersive experience challenged many of the faculty members to question their assumptions about the use of digital technologies in learning and has created a context for continuing dialogue.

## *Concluding Remarks*

In conclusion, we must acknowledge that life is challenging and full of unanswered difficult questions that we need to probe and try to understand. Educators urgently need to address the issue of what digital technologies can mean for learning. Rather than accepting others' interpretations, understandings and worldviews, everyone must ask their own questions and set their own learning agendas, to control their own destinies. Given that there are no "fixes" or "givens," no one can think for someone else or decide what they need; all individuals must do this for themselves. Dependency denies human potential. Dependency is a denial of the potential of the human being. Creating a state of dependency imprisons the human spirit and denies it the possibilities of reaching its potential. Denying this to someone robs them of their right to freedom and empowerment. By pursuing personally-chosen learning goals, we do not advocate a state of anarchical bedlam, with everyone pursuing their own quest in isolation without reference to others—because it is only in dialogue with others that we can come to true understanding: it is the "significant others" in our lives confront and challenge our own understandings and help us develop and grow. We can do so only in an environment that encourages critical questioning and constructive, challenging, yet respectful dialogue.

So learning involves immersion in this humanising culture, a willingness to be personally exposed and vulnerable, to experience pain, but at the same time to reach great heights. This learning requires honesty, trust and personal commitment; it returns self-fulfilment and communion with others. If policy makers are seriously interested in creating powerful learning environments in our schools, first they must ensure that the people responsible for nurturing these environments have personal experience of an equally powerful and empowering learning environment. Teachers need to be in control of their own learning. Society needs to acknowledge that it is healthy for teachers not to have all the answers, and that rather than viewing knowledge as coming in neat handy-packs for easy digestion, everyone needs to construct their own understandings. Currently, though, the way teachers themselves are treated with regard to their own learning does not promote an effective learning environment in our schools. In fact, they are not allowed to learn; instead, they are subjected to a barrage of inservice or "training" programmes designed only to implement the next designated externally-imposed, top-down reform of the education system.

Given the rapid rate of current societal change as globalisation and the proliferation of digital technologies spreads, with the demands of the "systemsworld" threatening to swamp and dominate the needs of the "lifeworld," I wonder whether society can afford not to invest in its teachers and, thereby, in the learning of future generations. I believe policy makers urgently need to ask themselves some very difficult questions. First, are we willing to allow teachers to learn so that future generations can control their own learning? Then, do we believe people can reach their full learning potential by setting their own goals? Or do we think that potential has to be checked and controlled by outside agencies?

Only by grappling fearlessly with these difficult questions and their multiple, complex answers, will we responsibly deploy the tools of our society, and influence the culture of future generations.

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# Appendix A

## *Empowering Minds School and Teacher Details*

| **School Details** | | **Teacher Details** | |
|---|---|---|---|
| **Name** | **Address** | **Name** | **Class (Grade)** |
| St. Brigid's NS | Castleknock, Dublin 15 | Terry Duffy | Computer Resource |
| | | Barbara Mc Donagh | 4th |
| | | Clifford Brown | 5th |
| | | Eimear O' Callaghan | 2nd |
| | | John Doyle | 4th |
| Holy Spirit Boys NS | Ballymun, Dublin 11 | John Kelly | Senior Special Class |
| | | Vivienne Byran | 4th |
| | | Cathal O Connell | Computer Resource |
| St. Patrick's NS | Corduff, Dublin 15 | Verena Cunningham | 4th |
| | | Caitriona Smyth | 3rd |
| | | Conal Barry | Home/School Co-ordinator |
| | | Rhian Morgan | Special Class |
| Redeemer Boys' NS | Dundalk, Co. Louth | Tom Murphy | 2nd & 3rd |
| | | Patsy Murphy | 3rd & 4th |
| City Quay NS | Sth Glouster St., Dublin 2 | Ruth Kirwan | 6th |
| | | Pat Bunce | 4th |
| St. Finian's NS | Newcastle Lyons, Co. Dublin | Joan O Rahilly | 4th |
| | | John Deegan | |
| Kill National School | Kill, Co. Kildare | Hannah Foley | 5th |
| | | Joan Bramhall | 3rd |
| Scoil Mhuire Gan Smál | Inchicore, Dublin 8 | Fintan Mc Carthy | 2nd |
| Dominican Primary Schol | Dún Laoghaire, Co. Dublin | Ursula Hearne | 3rd & 4th |
| | | Petrina Brophy | 2nd |
| Clontubrid NS | Freshford, Co. Kilkeny | Tommy Maher | 3rd,4th,5th & 6th |
| | | Mary Maher | Infants, 1st & 2nd |
| Kilvemnon NS | Mullinahone, Co. Tipperary | Teckie Brett | 2nd & 3rd |
| | | Conor Doyle | 4th, 5th & 6th |
| St. Joseph's NS | Ballyadams, Co. Kildare | Kathleen O Connor | 4th, 5th & 6th |
| | | Mairtín Mullooley | 1st, 2nd & 3rd |
| Stokane NS | Stokane, Co. Sligo | Vincent Mc Mahon | 2nd, 3rd, 4th & 6th |

# Appendix B

## *Development of the expressive computational materials*
## *A long tradition in the making*

As far back as the 1960s, when Seymour Papert was co-director of MIT's Artificial Intelligence Laboratory, he began to create a computer programming language for children. He wanted to encourage a spirit of inquiry amongst them and believed that their apparent deficiencies in mathematical fluency were attributable to a lack of challenging and engaging materials in their world. By creating the Logo programming language, he hoped to create an environment where children could work with mathematical ideas with the same personal meaning as learning a foreign language in their country of origin (Papert, 1980, p. 6)

Based on the programming language Lisp, Logo was a departure from other contemporary computer programming languages in that it was highly interactive. Other interfaces used batch-mode programming, but a child could type a Logo command, and the computer would execute it immediately, so the child could see the result of an interaction with the computer immediately.

Rather than confining themselves to data manipulation and transformation, Papert and his colleagues began experimenting with robots connected to computers that were running Logo. Children quickly identified with these robots as they found the robo-centric geometry easy to understand. At first, children played with the robots, using button-boxes to control the robot's motion. Later, they used Logo primitives to control the robots, typing instructions like

- FORWARD 25 [robot moves forward twenty-five "steps" ]
- RIGHT 90 [robot turns in place ninety degrees].

A pen attached to the robot's underside meant geometric patterns could be drawn on the floor if certain sequences of movement commands were typed. For example, if a child typed

- FORWARD 25 RIGHT 90 FORWARD 25 RIGHT 90 FORWARD 25 RIGHT 90 FORWARD 25 RIGHT 90 or

- REPEAT 4 [FORWARD 25 RIGHT 90],

the robot drew a square with sides of 25 "Turtle steps" in length.

This identification with the robot, later known as the Turtle, became the Logo environment's key feature as Papert noticed that children's interactions with the Logo robots were different in quality from those in other projects based on data manipulations: when working with the Turtle, the children could imagine themselves *as* the Turtle. Consequently, when they wanted the Turtle to do something, and they ran into a difficulty with how the Turtle should go about it, they could "play Turtle," and walk themselves through a Logo program as if they were the Turtle. They were able to think about the Turtle's movements by using their own bodies. This ability to think with their bodies, Papert called "body syntonicity," and was a key to Logo being more accessible to children across a broad range of intellectual styles.

When computers developed video display technology, the Logo Turtle migrated from the floor to the screen. The physical electro-mechanical Turtles were now iconic images of turtles on computer monitors. So now instead of moving around on the floor, when a child typed in a command the turtle moved about on the screen. This had advantages in that Logo could be used on any computer with a video display and so could reach many more children. These turtles moved more easily and precisely, which meant that children could create more complex graphics. A big drawback of the iconic turtle, however, was that many children had more difficulty understanding the turtle's rotations on the screen, as the iconic turtles moved much faster than the floor turtles. So they had a harder time visualising and understanding the rotation of the monitor turtle.

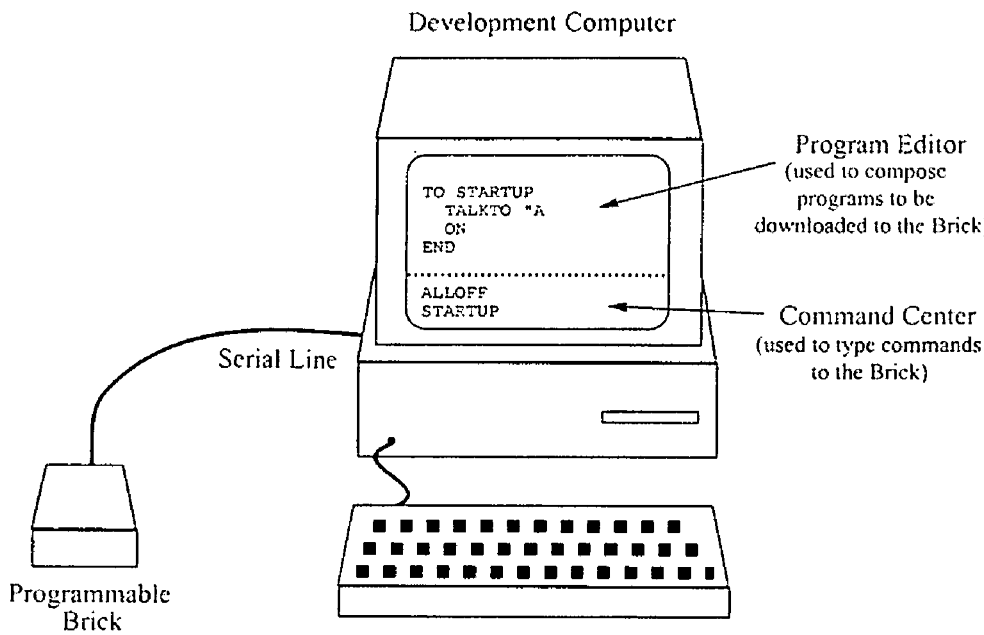
Development was ongoing in Papert's research group at MIT Media Lab and in the mid 1980s, Stephen Ocko and Mitchel Resnick began working on an interface that would allow children to build devices with motors and sensors that they could then program using Logo. They worked with a new product called LEGO Technic, which included gears, beams, wheels and motors in addition to the usual LEGO building bricks. These new pieces offered new opportunities for building exciting moving structures that were not possible before; in fact, the possibilities with these new pieces were endles. Serendipitously, around this time, the president of the LEGO company in Denmark read *Mindstorms* and realised that there was a shared set of ideals about the role of children's play in learning and the value of constructive materials in children's hands and minds. From this a sponsored research project developed that ultimately lead to the commercialisation of the LEGO/Logo system as a product for the educational market, which they named *LEGO tc logo* ("tc" for Technic Control). Papert's vision of a computer control mechanical devices, written in the days of the Teletype interface, had now been realised (Papert & Solomon, 1971).

However, the LEGO constructions had a major drawback: they needed to be tethered by wire to the electronic interface that was hooked up to the controlling desktop computer. So this interface actually encouraged the construction of stationary objects (e.g., traffic lights, a ferris wheel, or a merry-go-round) rather than truly mobile objects or creatures that could very quickly get tangled up in the tethering cable.

To get round this problem of the permanent tether, the next task was to develop an interface that would enable the programming of autonomous devices. Around this time, Fred Martin (with whom I have worked closely in the conception and development of the Empowering Minds group) "joined Papert's team to assist in the development of the "programmable LEGO brick—a hand-held LEGO box that contained an entire computer capable of running Logo" (Martin, 1994, p.50). Two others joined the development team: LEGO engineer Allan Toft, and Brian Silverman, chief scientist at Logo Computer Systems, Inc. (LCSI), who had done the software development of the Logo implementation used in the commercial *LEGO tc logo* product. In about a year's time they had created a prototype Programmable Brick that ultimately led to the LEGO retail product known as MindStorms Robotics Inventions System.

The prototype Brick was based on a version of the 6502 microprocessor (the same device that had been used in the Apple II series of computers). It had outputs to control four LEGO motors, and inputs to receive data from four sensors. LEGO's existing touch switch and light sensors as well as custom built sensors could be used. LCSI's commercial version of Logo was used as the programming environment and the Brick was connected to the computer by a serial line connection that enabled the user to type commands to the brick or download Logo procedures to it.

*Figure 1.* The Programmable Brick System (Martin, 1994, p.51)




While functioning like the commercial *LEGOtc logo* product when tethered to the computer, the LEGO Brick had the advantage of being able to function independently once disconnected. The downloaded program could then be initiated by pressing a button on the Programmable Brick. This breakthrough enabled building and programming autonomous devices. The need for a permanent link to the desktop computer had finally been severed as the computational capacity was now embedded within the object that had been constructed by the child. The constructed object had, as it were, an independent existence, and children could relate in a meaningful way to these new objects in much the same way as they had done with the original floor turtle. Now these objects could not only be controlled by the learner but also could be conceived, designed and constructed by them, as well, thus adding a degree of personal engagement and immersion in the learning process that had not been possible before. Researchers at the Media Lab, especially Edith Ackermann and Fred Martin, used the Programmable Brick system with a small group of fifth grade students to explore ideas about cybernetics, feedback, and anthropomorphization (Ackermann, 1991; Ackermann & Martin, 1988).

The MIT team continued to develop the concept throughout the 1990s. Work included technologies used in under-graduate engineering education (Martin, 1994) and smaller programmable bricks called "Crickets" which have been used in scientific investigations with school children (Martin, et al., 2000).

A late MIT prototype of the Mindstorms concept was used in an integrated, project-oriented fashion in the Peacedale Elementary School in Rhode Island (Martin, 1996). The Empowering Minds work shares the cross-curricular approach used in these classrooms. A related yet original approach to bringing this robotic technology to children is proposed by Bers and Urrea (2000). In this project, children, parents, and teachers at a Jewish community centre explore spiritual values using the Mindstorms technology. The Empowering Minds work shares Bers and Urrea's focus on the narrative, story-telling ingredient of children's technology projects.

The LEGO Mindstorms product, a robotic construction kit based on the Programmable Brick developed at the MIT Media Lab was launched by the LEGO Group in 1998. These commercially available materials formed the core around which the Empowering Minds project developed.

# Appendix C

## *EM Project Materials supplied to each classroom*

| LEGO Dacta Product No. | # per classroom | Product Description |
|---|---|---|
| | 5 | Team Challenge Set (2 motors, 2 touch sensors, 1 light sensor, RCX Brick, IR Tower) |
| 9780 | 1 | Robolab Starter Set |
| 9709 | 5 | RCX |
| 9609 | 1 | Tech. Resource Kit |
| 9610 | 1 | Quickbuild Gears Set |
| 9612 | 1 | Quickbuild levers Set |
| 9614 | 1 | Quickbuild Pulleys Set |
| 9616 | 1 | Quickbuild Wheels & Axels Set |
| 2009620 | 1 | Gears Teachers' Guide |
| 2009622 | 1 | Levers Teachers' Guide |
| 2009624 | 1 | Pulleys Teachers' Guide |
| 2009626 | 1 | Wheels & Axels Teachers' Guide |
| 9899 | 4 | hubs and tyres |
| 9943 | 4 | axles and extenders |
| 9927 | 6 | red beams |
| 9928 | 6 | blue beams |
| 9942 | 2 | connectors and bushes |
| 9900 | 4 | small gear wheels |
| 9966 | 4 | large gear wheels |
| 9939 | 2 | assorted pulleys |
| 9933 | 8 | red basic bricks |
| 9934 | 8 | yellow basic bricks |
| 9935 | 8 | black basic bricks |
| 5225 | 4 | 9v motor w/gear reduction |
| 5119 | 4 | 9v micro motor |
| 9929 | 2 | red plates |
| 9930 | 2 | blue plates |
| 9931 | 2 | yellow plates |
| 9932 | 2 | black plates |
| 9937 | 2 | small chain links |
| 9938 | 2 | conveyor belt links |
| 9958 | 2 | special elements for 9701 |
| 9738 | 1 | Remote Control |
| 9723 | 1 | Cities & Transportation Set |
| 9293 | 1 | Basic Community Workers |
| 2009723 | 1 | Activity pack for Cities and Transportation |
| 2009790 | 1 | Activity Pack for Team Challenge |
| 2009780 | 1 | Robolab Activity Pack |
| 2000041 | 1 | Robotics Concept Guide |
| 2009631 | 1 | Simple&Powered Mechanisms Notes |

# Appendix D

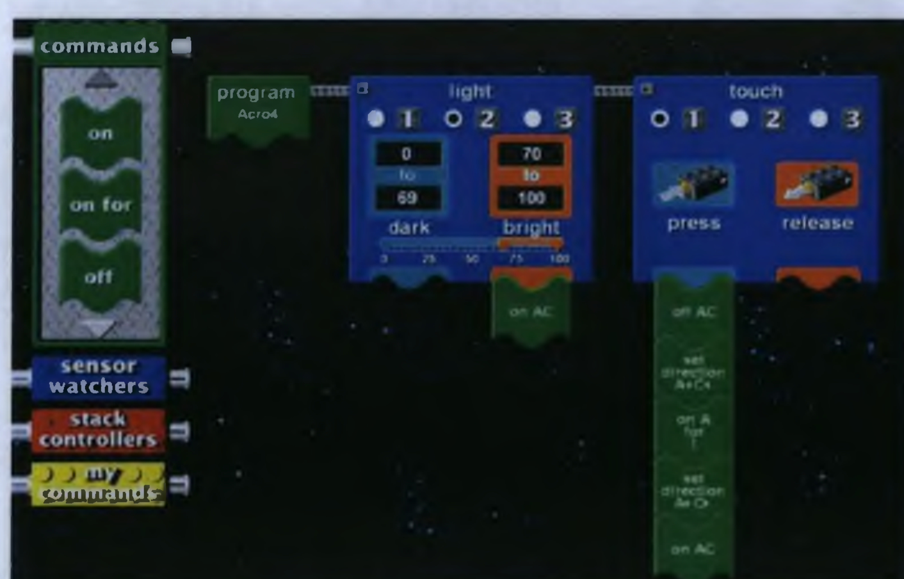
## *Common Problems experienced with the Computational Materials*

### *The pluses and minuses of Software Environments used in the classrooms*

The Mindstorms system is provided with two different software environments: *RCX Code*, supplied with the retail toy-store version, and *Robo-Lab*, generally supplied with the school versions. The teachers in the project found the Robo-Lab interface unnecessarily complicated, and they chose to use the RCX Code software. (Many other programming environments developed by Mindstorms enthusiasts are available, but the majority of these are suitable for programmers rather than being designed for children.)

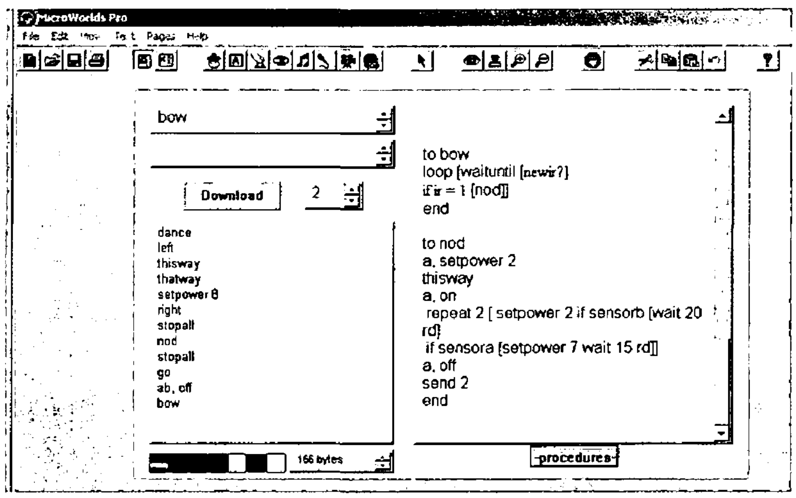
Using the RCX code software, one constructs a program by snapping together puzzle-piece-shaped screen icons, each containing a single command. Special "sensor watcher" blocks are continually testing a sensor condition and executing the stack of blocks connected underneath when the sensor condition becomes true. This multi-tasking capability makes constructing certain behaviours much simpler, but can also be confusing to children.

*Figure 1: RCX Code Programming Environment*




One of the teachers in the second group who joined the Empowering Minds community in August 2000, had been using the computer language Logo with the children prior to getting involved in the project. He expressed an interest in using Yellow Brick Logo as well as the RCX code for programming the models that the children were making. Yellow Brick Logo is a development of the Logo programming language developed by Seymour Papert and was made available to us by the Media Lab at MIT. These children from Stokane used both programming environments (RCX code and Yellow Brick Logo) to program the models they made and also used LCSI's Microworlds to program and develop an adventure game based on the legends and folklore of their locality.

*Figure 2: Yellow Brick Logo Programming Environment*




Each programming environment has its advantages and drawbacks. The decision to use the commercially available programming languages initially, rather than using the Yellow Brick Logo programming environment was based on the rationale that the icon based interface would enable more children to program.

### *Iconic interface*

The iconic interface appeared simpler as it was based on a click and drag method of constructing a program by snapping together puzzle-piece-shaped screen icons, each containing a single command. This eliminated the necessity to type and would minimise common typo errors that could cause a program to crash. It also meant that children who could recognise single whole words but could not yet spell were not disenfranchised and could program effectively. We thought this graphic iconic environment would also free children from focusing attention on syntax and spelling so that they could focus on the programming of their models and how they could organize their program to emulate the behaviour they wanted their model to display.

Errors in programming did occur in the iconic-based environment and led to the development of some misconceptions. A common one was the placing of a chunk of code (number of jigsaw pieces) under the wrong sensor watcher, e.g., the behaviour that was to be executed if the light sensor was reading dark under the wrong sensor. This type of programming mistakes is hard to track down, as the computer won't find the error for you.

### *Light sensor readings*

Light sensor data interpretation was counterintuitive for many people in that the numbers with the highest value were dark readings while the numbers of lowest value were the readings from the lighter colours. Despite many explanations and demonstrations about reflective and ambient light, many of the teachers and children thought that it made more sense to them if the readings of the light sensor had been recorded in the opposite way. To them a high numeric value meant there was lots of light, so the surface must be bright (a light colour), and if the numeric reading was low, then there must be very little light, so the surface must be a dark colour. However the inverse was in fact true.

### *Error messages and debugging*

Another drawback was that the RCX code generated no error messages, so learners had no idea where the programme had run into difficulty and had stopped functioning. At least with the Logo environment, even if the message was hard to interpret, the learner at least knew where the programme was having difficulty. So debugging with the RCX could become onerous and working systematically down through the list of instructions was generally not considered an option as this process was extraordinarily time consuming: each programme change to the Brick had to be downloaded and tested, and then tested again by running the designated program channel. So most people guessed where they thought the difficulty might be, and then relied on trial and error.

### *Direct test mode*

Despite its drawbacks, the RCX code environment was thought to be a short-term suitable introduction to programming which could then lead on the more powerful Yellow Brick Logo environment. The reasoning behind this decision was consistent as the older Yellow Brick Logo environment described above was in the process of being updated to an iconic interface and was due to be available within a year of the start up of the Empowering Minds project. However, much to our chagrin, development of the iconic-based programming environment was then exclusively focused on the Logo that was to be used with the new generation of a smaller Programmable Brick, the Cricket.

So we are still living with what is possibly the biggest drawback of the RCX code: it does not have the facility of the Logo interface that enables the learner to test directly with the brick. Yellow Brick Logo has a Command Center, in which users can type commands that are executed immediately after the enter key is pressed:

a, on [Turns motor a on and it continues to run until it is instructed to turn off]

a, off [Turns motor a off].

This facility enables users to test directly before putting sequences of commands together. It especially favours the learning style of the bricoleur, who likes to tinker and play with different commands as they develop their program. Such immediate feedback encourages regular testing, which can reduce the development of misconceptions. With the RCX code, however, this facility is not available, which means that commands have to be downloaded to the Brick and can only be observed when the button on the Brick is pressed to activate the correct program that the command has been downloaded to – each brick can store 5 different programs. With this extra layer, consequences of particular commands take longer to become visible. It encourages the building of long strings of commands, as it seems a waste of time to download a single command at a time. Having these long lists of commands increased the chances of bugs in the program. The same clunky download process also hinders debugging. It is quite cumbersome to work step by step through a program, testing each command by downloading them one at a time. Many times, we found that users then could not remember what they had downloaded and changed as a result of observing the command in action, which further complicated the debugging process.

### *Regular testing and Classroom constraints*

The practice of not testing regularly was also compounded by the pressure of time while programming. In the majority of the classrooms only one computer was available for programming, and inevitably there were several groups waiting to work on their programs at the same time. In many classrooms children where forced into working on their programs without the use of the computer. They worked collaboratively on paper or a whiteboard, discussing, drawing and writing the commands they thought were necessary for their model to perform the action they desired. Because of constraints of the programming environment and the lack of hardware, children often were forced to work in a style more closely related to that of the planner than the bricoleur.

# Appendix E

## *Overview of workshops /Support structures (1999 – 2003)*

### *The Initial Workshop, April 1999*

Each school sent two teachers to the workshop, with the exception of St. Brigid's in Castleknock, who sent their computer resource teacher along with two class teachers. This teacher was very interested in working with the materials and would be 'an extra pair of hands' in the project teachers' classroom.

The workshop was held at St. Patrick's College and ran for five days over the Easter holidays. For the first two days, in addition to the teachers, we also invited two parents and four children from each of the four selected schools. We spent the final three days working exclusively with the teachers chosen for the project. This format was an interesting innovation: the children's infectious enthusiasm contributed to everyone's excitement and built a great base for subsequent parental involvement.

The days with the small group of teachers were focused and productive. In this workshop, teachers were asked to design their own projects – for many, a novel experience. They all engaged wholeheartedly with the materials and were so immersed they were reluctant to leave even for lunch. There were times of frustration as they struggled to achieve their goals. Ultimately, however, they achieved success and the sense of accomplishment was palpable. These experiences opened up many conversations about how to implement this approach in the classroom and how to get the children started—whole class at once or sub-groups? From the beginning, everyone realised we would be relying on the intuitions and expertise of the teachers to implement classroom models effective in their own particular situations.

### *Exploratory Work in Classrooms, May - June 1999*

After some problems, the materials were procured and delivered to the schools (cf. Appendix B for a full listing of materials supplied to schools), with approximately four weeks left in the school year. This was just enough time for teachers to bring the materials to their children on a limited scale, and for the teachers to obtain practical experience that would serve as the basis for subsequent reflection in the summer workshop. The exploration with the materials before the second workshop proved valuable in many respects – not only for the direction taken in the second workshop, but also for the teachers' implementation approach for the autumn term. The teachers made specific requests for the workshop content as they realised the need to develop their own understandings of the principles of building solid structures, how gears worked, etc. We acted on these inputs and the second workshop was designed to accommodate the teachers' expressed needs.

### *The Second Workshop, August 1999*

Luckily, we were able to bring in John Bilotta, a district technology co-ordinator with over twenty years of primary classroom experience, who had participated in previous MIT research on Programmable Bricks. We used a substantially more structured format in this second workshop, providing teachers with focused half-day experiences rather than a multi-day, open design process. These half-day, focused activities proved invaluable for helping the teachers gain some important insights. For example:

#### *The Silent Game*

In this activity one person improvises a model, another responds by adding on to it, and a third observes. Although the Builders spent less than 20 minutes producing the models, many had a strong sense of it being *theirs,* and had mixed feelings about the Responders adding on to them. The Observers highlighted the different possible interpretations of the Builders' intentions. For the teachers, this process crystallised the need to respect children's sense of ownership, and made them realise that it is hard to tell children's intentions from only seeing snapshots. This was brought into relief for the group by Joan's response to John's model. He hadn't intended to make a pattern, but she replicated his model, taking something that he intended as random, and making it a clear pattern.

#### *Slow-car Building Challenge*

This challenge (to build the slowest car possible that still moves) drove home the theory and practice of gear reduction, and pointed out the complexity of designing successful models. One group had lots of trouble building the supporting frame around the gears and didn't finish until the next day. Another group's car fell on the floor and smashed to a thousand bits. They commented that it was the best thing that could have happened: they needed a full redesign, but had not been prepared to take their model apart!

### *Easter Review, April 2000*

The "Big Event" (The Young Inventors' Robo-show) was held at St. Patrick's College on Saturday, 15th April. All the participating teachers and children came to celebrate and share each other's work. Each school informed the parents about the Robo-Show, and we sent an open invitation to groups we thought would be interested in seeing the projects developed by the teachers and children. There was an unprecedented turnout not only from parents and people directly involved with the project schools but also others involved in the education field, including practising first- and second-level teachers, students and faculty from universities (e.g., the entire M.Sc. class from Trinity College, faculty members from University College Dublin, Dublin City University, University College Cork, National University or Ireland Maynooth, Blanchardstown Institute of Technology). NCTE's ICT advisors came from Dublin, Kildare, Laois, Wexford and some from as far afield as Limerick and Sligo. It was a very successful day and we came away with numerous requests from teachers to be included in the next phase if we were expanding the project.

The following Monday through to Wednesday, we meet the group of project teachers to share and review the year's work and to discuss future plans. Release days and substitute teacher cover was again provided for those teachers whose schools had not yet closed for the Easter vacation. One of the outcomes of this very fruitful few days was a compilation of ideas for others who may be interested in working with these computational materials (http://empoweringminds.mle.ie/documents/one-doc?id=233 ). All the teachers expressed the sentiment that they felt they were beginning to come to terms with the new materials and the new approach to learning. They felt that they were really only now coming to understand what could be possible in the future and they wanted continue if it were possible. As a result of this extremely positive feedback it was decided to seek funding to expand the project for another year and explore in more depth what could be achievable using these materials and this Constructionist approach to learning.

### *Summer Workshop, August 2000*

I compiled a mailing list of all teachers who had expressed a serious interest in being included in the next phase (e.g., they had attended many of our open evenings or talks and had registered their interest by writing / emailing me). These interested teachers were all invited to a special information meeting to discuss the implications of being involved in a project of this nature. Fred Martin, all the project teachers and I attended to give an open and honest appraisal of what was involved. As with the first set of teachers, participation by prospective new EM participants was entirely voluntary. Our other conditions were: two teachers from each school and the support of the school's principal. More teachers were interested in participating than we could include, so it was decided to focus on targeted expansion on small rural schools, disadvantaged schools, a single sex school and children with special needs. We based this decision on a number of factors. For very different reasons, the small rural school and the inner city schools would previously have considered themselves disadvantaged – the rural schools, because of their location and size; and the inner city schools, because of the lack of relevance the curriculum held for the children that attended these schools. In the initial four schools, however, these disadvantages were not apparent; in fact, both types of schools thrived on the new learning experiences. The small school had the advantage of smaller numbers and the fact that the same children would be continuing with the teacher for a number of years meant they could continue building on the learning experiences of the previous year. Whereas in the larger schools, the teachers were going to have a different cohort of students each year, so they would not be able to explore at real depth, over a number of years, the possibilities of the computational materials. The inner city school's horizons were thrown open with these materials, as they did not dictate the direction or content that had to be covered. The decision of how the materials were to be used was in the hands of the children, who revelled in the chance to explore concepts using a different and less limiting set of expressive materials.

Working with children who had been labelled as having special learning needs was going to be interesting as, in the first year so many of the "less academically able" children had come to the fore in all of the classrooms. Perhaps the existing educational system was "less able," and not the children it supposedly served. Finally all the schools in the first year were mixed sex and we wondered if the materials would open up different possibilities in single sex schools. Unfortunately there was no application for inclusion from an all girls school. In the second group of teachers therefore we could only include teachers from all boys schools. The selected teachers and the teachers from the first group were then invited to attend a five-day summer workshop at the end of August.

We organised this workshop along the same lines as the previous ones with the emphasis on 'hands-on' experimentation, reflection and discussion. Along with Fred

Martin and me, the first group of teachers acted as facilitators and mentors for the large group of 20 new teachers. The new teachers, although initially anxious, appeared to settle in much more quickly than had their predecessors—now their mentors—the year before, who brought this to our attention. When we asked the new teachers about it, they all replied that they knew it was going to be hard work in the months ahead, but they were enormously comforted by the fact that a group of teachers had gone before them, paving the way—and they "had all lived to tell the tale!"

This is how one of the teachers put it in her end-of-year report:

> "Last August I took the trip to St. Pat's totally oblivious as to what I was letting myself in for! But when I was confronted with boxes of Lego, containing more pieces than I ever knew existed, and asked to 'build' and, even worse, to build something that moved, I started to worry! But there were those who had already survived a year of this Lego in the classroom and had plenty of tales to tell, most of which didn't sound too horrific! So I decide to believe the teachers who claimed that it didn't matter that they were not Lego experts or even that mechanically minded as the children soon made up with enthusiasm what we lacked in expertise. And so I put my fears a little to the side and basically just got on with it!"

The new group of teachers also felt that if they ran into difficulties or had questions to be answered they had a group of veterans they could call on for advice and help. What did not work as well, however, were the group discussions as the group was too big to discuss any of the issues raised in real depth, and it was not possible for everyone to contribute fully. The discussions with the first group of 9 teachers the previous year had been very successful. The teachers all expressed an interest in being able to meet before the end of the first school term and discuss with other teachers in the group how things were progressing in their classrooms. Therefore it was decided to reduce the new group size to more manageable clusters of approximately 9 teachers to facilitate discussion and the sharing of ideas. Three clusters were formed for our next meeting:

- North Leinster Cluster (Castleknock, Corduff, Dundalk, Ballymun)
- South Leinster Cluster (City Quay, Inchicore, Dun Laoghaire, Kill, Newcastle)
- Small Schools Cluster (Ballyadams, Clontubrid, Kilvemnon, Stokane)

### *Cluster Meetings – December 2000*

Fred Martin and I met with the teachers in the North Leinster Cluster teachers on Monday, 4th December, and with the South Leinster Cluster teachers on Tuesday, 5th

December. The teachers were released from school with substitute teacher cover, and we met at St. Patrick's College. The teachers spent the day sharing with each other what they and the children had been doing with the materials, the problems they were experiencing, and ways to build on their work for the next school term. A buddy system was set up, and teachers planned to email or phone their buddies at least once a week to share their classroom experiences.

We could not get the teachers from the small schools released, as this would have involved closing the schools due to the lack of substitute teachers. Instead, the teachers suggested that we meet the teachers from three of the schools in Kilkenny for a three-hour meeting on the evening of Wednesday 6th December, and have a workshop on Thursday, 7th with all the teachers and children together (approximately 100) in the Kilkenny Education Centre. This was a very successful arrangement if a little hectic! The remaining small school was a long distance from the others (three-hour drive) so we drove to them for Friday, 8th which was a church holiday, so the school should have been closed. The teachers, children, some of their parents, a teacher from another local school and the region's ICT (Information and Communications Technology) adviser all joined us for a long morning workshop.

### *Action Research and Dreamweaver Workshops – February 2001*

When we negotiated with the NCTE to obtain funding for the expansion of the project to the second group of teachers, release time again was an integrals part of the proposal. The type of workshops had not been determined in advance, as I explained that the teachers' needs and interests would determine the structure and content of these workshops. Our only certainties were that there were to be a set number of days set aside for workshop development, review and reflection. This was a major departure from the usual model of teacher development, where the structure and content of any course / workshop is predetermined and generalisable for a blanket delivery to teachers.

The teachers' expressed need of being part of a larger group within which they could comfortably share ideas was invaluable in forming a common focus and cohesion to the group. It was not always feasible to have face-to-face meetings so we had to think about alternate ways of sharing experiences. In response to feedback from teachers, we arranged a two-day workshop to explore the issues of how to try and record what was happening with their own and the children's learning. Jean Mc Niff, contracted by the NCTE to work with all SIP projects to evaluate the impact of the SIP programme, was the facilitator of the Action Research Day. She explored with the teachers ways of understanding the changes in their learning and teaching and how best to capture classroom incidents / stories to illustrate them.

Teachers discussed ways of sharing what was going on in their classrooms, and they thought that a website for each of them might serve as windows into their classrooms. We reviewed a variety of software; most of it was found to be too restrictive or had a long learning curve, but Dreamweaver was considered to have a low threshold and high ceiling. As a result of the web development workshop some of the teachers began to develop their own websites, and the group hoped for further web development workshops in the future, as many of the teachers are keen to develop a stronger web presence. However, as will be discussed later, most of the teachers found prohibitive the time and the technical skill necessary to develop a web presence. They also felt if each school worked away on their own website, they would perpetuate a fragmented approach, so they wondered if it was prudent to develop a project web presence.

### *Review Day – 19th June 2001*

We would have preferred to have more than one day for this review but because of a shortage of substitute teachers, we could only have one. In the morning, we attended a talk at St. Patrick's College, by Seymour Papert and we all joined him for an informal dinner that evening. This was a wonderful opportunity for the teachers to meet and talk with this world-famous thinker and the inspiration for the project. For the afternoon, we reviewed the high and low points of the year's work and identified where we should go from here. We agreed to continue these discussions at the summer workshop to be held during the last week in August (27th – 31st inclusive). For the summer workshop, the teachers asked for more input on web development, exploration of the cricket technology and Microworlds Pro and if possible some sessions on digital video use and editing.

It was at this point that a decision had to be made about whether to expand the group and include more schools or to maintain the existing group but delve deeper into using these computational materials. We decided in consultation with the group that we would not expand but would instead concentrate on trying to understand the type of learning processes that teachers were now witnessing in their classrooms. In addition we would expand the palette of digital tools available for use in response to the teachers' expressions of interest to date.

### *Classroom visits*

During the first two years of the project's development, I spent a lot of time in classrooms alongside the teachers working with the materials. This way, I could engage in problem solving scenarios using the materials in a variety of contexts. This not only gave me a real flavour and understanding of how the children and teachers were using the expressive computational materials, but it also let me see how the teachers interacted with the children. From these observations, together with many conversations and in-depth interviews, I was able to build profiles of what I thought each teacher's learning philosophy and preferred mode of interaction was. And the teachers got to see and experience my interactions with children, so they were able to make useful style comparisons. The teachers valued these visits highly because:

- The fact that I came to their classroom signalled to them that I thought the work they did was important.
- They had opportunities to ask questions and discuss issues that had arisen as a result of working with the materials.
- My observations of what was happening in the classroom during the building sessions provided another perspective on the learning that was in progress.
- The teachers an opportunity to stand back and observe what was happening as the children were engaged with the materials.
- I brought them up to date on progress in the other schools, so they felt they were part of a group working together.
- The visits signalled to the other teachers and the principal that this was a serious project and not some 'flight of fancy' on the teacher's part because someone from a third-level institution thought it important enough to visit on a regular basis.

This flexible support structure of visiting classrooms provided the informal help, advice and encouragement that all teachers need on an ongoing basis. It also gave me insights into the problems and difficulties they were experiencing, which helped me understand the context for their needs.

During the second year of the project, this class-visit support structure was extended to include the teachers from the original group, as they had been using the materials in their classrooms for over a year and could offer very practical advice and support. Many of the new teachers made local arrangements to visit the more experienced teachers' classrooms to see first-hand how they were working with the materials. For my part, and because the project had now expanded to twenty-four classrooms instead of the original eight, I concentrated on visiting the new teachers, but I did still manage to visit the original teachers occassionally.

## *Watershed*

Over the summer of 2001, a number of developments significantly altered the path of the project's development and coloured subsequent events. First was the inaugural Learning Hubs Summer Institute held in Mexico for two weeks in July 2001 and organised by the Future of Learning Group at MIT, Media Lab. Six of the teachers and I participated in this event. Our learning experiences at the Summer Institute contributed enormously to the personal development of several individual members of the group, who later emerged as leaders in different ways, but it also strongly influenced the new computational tools and materials that the other teachers began to use. I will return to discuss this at greater depth later when I outline some of the in-depth case studies and learning stories.

During the summer of 2001, when NCTE decided to cease all funding for SIP projects, the group had to seriously reappraise priorities. Fortunately, this did not sound the death knell for our project as it did for those who were totally reliant on this source for their project funding. We had the opportunity of receiving funding from the HEA through the MMR collaborative fund that was set up to encourage collaborative research projects between Media Lab Europe and Irish third-level institutions. However, we had to reconsider the developments the teachers had indicated and that we had been planning (e.g., exploring the possibilities of Cricket technology). Loss of funding was one concern, but equally crucial was the official sanction of release days, with paid substitute teacher cover. As the NCTE was withdrawing support for SIP projects, there would be no official mechanism to sanction the teachers' release from teaching duties. This would be the crunch factor, I felt, in deciding the future of the project because its development depended so much on the teachers feeling part of a group and having time out together to develop their needs and interests. Would they be willing to commit time and energy to coming together in their own time after school hours? And would the project maintain its level of support from the principal and parents, now that the 'official stamp of approval' had been withdrawn?

The teachers' commitment to the project was not swayed by the withdrawal of release days, perhaps because by the time official sanction was withdrawn the teachers had bought into using the materials and the philosophy behind them and were willing to continue themselves as a group, whatever it took. They could see the concrete benefits for themselves and the children, and were committed to continuing. As the funding was not going to be available to explore all the avenues the teachers originally had intended, they had to prioritise their needs. Now that they could not come together as often or as easily as in previous years, when release time had been sanctioned, they decided that communication and the sharing of ideas and expertise was to be their first priority. However, as only one of the schools (Stokane N.S.) had access to the web in their classroom, a concerted effort would have to be made to have connectivity brought to all the project classrooms. We thought wireless hardware was the most appropriate solution to this connectivity problem as it would enable multiple machines to access the web from the same connection without having to interfere with the structure of the school to install cabling. This proved to be a long and difficult learning experience for the group but we did succeed in most of the group achieving connectivity in their classrooms by the end of the 2001-2002 school year.

Connectivity was only one part of the solution to this two-part problem. In addition to having connectivity, teachers needed a platform on which to share their learning experiences and get help and support. As noted previously, many of the teachers did not succeed in developing their own websites for a myriad of reasons, top of the list being lack of time and technical expertise. To get round these problems a web platform (http://empoweringminds.mle.ie ) was designed and developed with the teachers (Butler et al. 2002) and they are using it to collaborate and share their distributed expertise.

Without official release time the group was restricted to having workshop sessions during vacation times or at weekends. The major teacher workshops were held during the summers of 2001, 2002 and 2003 and ran over five days.

## *Overview of workshops /Support structures (2001 – 2003)*

### *Summer Workshop, August 2001*

Because we knew that Fred Martin was coming, and we were still optimistic about funding, the group decided to go ahead and explore the Cricket technology as a development and an extension of the Programmable Brick technology. Teachers and children had been requesting a smaller programmable unit to work with, as they felt the size and weight of the yellow brick was inhibiting construction of particular types of models and artefacts. Fred Martin, who had been part of the development team for the cricket technology, myself and some of the teachers who had been to Mexico, worked with the other teachers making sensors and used this smaller programmable unit to develop projects.Many of the teachers had also expressed an interest in learning more about how to use digital photography and video to tell a story and capture some of the learning they were observing in their classrooms. Glorianna Davenport, who directs the research of the Interactive Cinema group at MIT ML, had developed a strong interest in the teachers' work, so she volunteered to come along and work with them. She asked the teachers to bring along some of the pictures they had already taken and, using these as a starting point, she explored issues of light and perspective as well as trying to help the teachers articulate the story they were trying to tell with this picture or series of pictures. Gradually the teachers began to realise how digital imagery can be a powerful medium for expressing meaning.

*Figure 1: Teachers working collaboratively*

*Figure 2: Glorianna Davenport discussing the use of imagery with a teacher*

At this workshop, we saw real evidence of the group's expansion to include individuals from many different fields. Besides Fred whose background is in engineering, and Glorianna, who is a film-maker, visiting from Thailand was Kuhn Bangkok, an influential businessman and key player in Project Lighthouse (Cavallo 2000). He had come to talk and work with the teachers as a result of feedback he had received about the project from Savalai Vaikakul, a student in the Future of Learning group at MIT ML, who had been at the Summer Institute in Mexico. She had been impressed by the interaction of the Irish teachers who attended the Summer Institute and the ways they based their learning around the theme of story and the rich cultural heritage of Mexico. Chun Bangkok was intrigued and wanted to work with the Irish teachers to learn more about their approach to learning and the ways they were using the digital technologies, as he thought the teachers in the new Constructionist school they had established in Bangkok might take this route to approach learning.

Another visitor to the workshop, Inmaculada Caruana, from Alicante in Spain, (http://www.teddi.ua.es/ ) was interested in learning more about how these Irish teachers were trying to define what being digital meant in learning. She had visited a number of our project classrooms earlier in May 2001 and had come to our summer workshop with one of the teachers she was working with in Spain as they were trying to develop a similar project in schools.

As a result of the HEA collaboration with Media Lab Europe, we met with faculty and students of the NCSR (National Centre for Sensor Research) from DCU and invited them down to share the work they were doing developing sensors for use with the Cricket and the Programmable Brick. This has since developed into a collaborative project, with some of the teachers and children using these sensors with the Programmable Brick to investigate environmental monitoring and data handling.

### Group meetings

The group tried to supplement the loss of release days by meetings in the evenings. These were generally held at St. Patrick's College as it was a central location, and we had access to the facilities we needed at no charge because I was a member of staff. There was at least one group meeting per school term, or more frequently if an issue was causing particular cause for concern, e.g., network problems with the wireless hardware installation and configuration. Detailed notes of each meeting were recorded and posted on the website for those who had not been able to attend (http://empoweringminds.mle.ie).

My role changed, too. As the teachers became more confident, they turned to each other for help and support, so I was able to stand back, and my visits to schools were few and far between.

### Summer Workshop, August 2002

At this workshop, we began to see concrete evidence of the group really becoming self-directed in their learning. During the group meetings preceding this workshop, they collectively decided on the areas they wished to learn more about, and began to plan accordingly. The teachers who had organised similar sessions for the end of year get together for all the schools took responsibility for organising whole day sessions based around the following themes:

- RCX programming
- Claymations using Microworlds
- Video shooting and editing
- Data logging using the software and sensors developed at NCSR

I had very little input during this weeklong workshop except to organise the use of some rooms and access to the college's computer labs, in addition to facilitating some group discussions about future plans.

This autonomy demonstrating control and ownership of their own learning was also very evident in the teachers's decision about ways they were going to spend the hardware grant money that their schools received from the NCTE. Unlike the majority of teachers, who had not been involved in thinking about learning and working with a range of expressive computational materials, the teachers in the Empowering Minds project had personally matured and developed in their thinking over time, so they could now take responsibility for their own learning and the use of digital tools and materials. They were in a position to decide where they wanted to go next and why. Many of the teachers bought iMacs for video editing, a unique decision as the majority of hardware used in Ireland is PC-based. Others extended the wireless infrastructure so that the entire school had Internet access. They knew what hardware they wanted to buy in order to pursue and develop not only their own interests and needs, but also to develop and explore the interests and needs of the children they worked with, as co-learners.

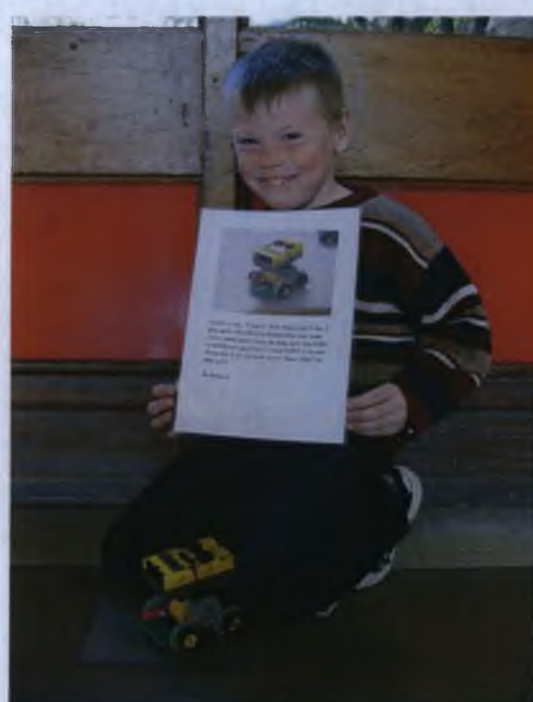
# Appendix F

## *Classroom experiences which confronted the teachers' deeply held beliefs about learning*

### *Seeing is believing - Shifting values*

The teachers observed a myriad of changes in their classrooms. Foremost, perhaps was that the children's perceptions of themselves changed as "they came to see themselves as designers, builders, programmers and that they could succeed at a high-profile task." (Tom's Report Summer 2001) – as in Figure 1, below.

*Figure 1: "Proud as punch"*



All the teachers echo this ownership and pride the children had in their work. As one teacher commented, "from the very beginning probably the most notable feature of our Lego sessions was the pride the children took in the most basic of models they built! ... They were proud of something that they had achieved. They felt that it was something wonderful and unique and because it got so much attention from other children around the school this opinion was reinforced!" (Caitriona's report Summer 2001). Many of the teachers commented that this was in fact how they had felt when they had built their own models with the materials. It was also something that they observed when they worked with other teachers in workshops.

Solving the problem was important to the children because they felt personally challenged. The teachers felt that this sense of achievement was strongest when the problem they and the children had been working on was particularly difficult. In fact, the children in Clontubrid adopted the motto "the only problem worth solving was one that fought back".

Teachers also regularly observed that

> whenever a model was built, it was the weaker children in particular who wanted to go around the school to show it off. Their pride in their work was very evident. The more academic children seemed more content to stay in the class and continue, they did not seem to need the same type of encouragement. (Vivienne's report , Summer 2001)

Many teachers began to wonder if this were the case because the "more academic" children already are recognised and constantly affirmed by the existing system, and therefore do not need the extra acknowledgement. Or was it that the other, "weaker" children now had an opportunity to feel good—for the first time—about something that they had done in school?

As the project progressed "it seemed that some of the children were more suited to learning in this way, through constructing their own learning environment, and others did not involve themselves as deeply as they might have" (Conor's report Summer 2001) Many of the teachers were "very surprised to discover that a few children who would be normally top achievers in the class were sitting back and reluctant to take part." (Conor's report Summer 2001) This unaccustomed reticence occurred across some classrooms frequently throughout the year, and one of the teachers commented that "the only conclusion I have come to is that they felt intimidated by the fact that children, over whom they usually shine, were as good and often better than they were" (Caitriona's report, Summer 2001).

Many other teachers commented that it was the

> weaker children especially who showed increased motivation and higher self-esteem...were much happier in school and were very capable using the Lego materials. This sense of achievement was usually absent from their other experiences in school. (Cliff's report, Summer 2001).

This is in stark contrast to the consistently observed engagement and achievements of these children who would not have been considered "top of the class" in the traditional subjects. As the teachers in one small rural school reported,

> Three boys in particular grew in confidence, not just in Lego building but also in their interaction with other pupils and in classroom activities. They found they could build gates with sensors and motors, rising drawbridges, a pulling mechanism to pull figures up our mountain, and they could grasp the programming elements of the project. Indeed for us the great success was to see children sitting discussing and making changes in the programming, or changes in the building of a model. In these situations it was often these non-academic pupils who were pointing out the changes because it was they who had engaged most fully with the actual building of the model in the first place, and so knew exactly what was required to make the model behave in a certain way. (Conor's report Summer 2001)

Teachers also observed that children who were having difficulties with school showed a determination and persistence when working with the Lego materials that was missing from the more formal schoolwork. As an example, some seven- and eight-years olds in one classroom were described as children "who had difficulty concentrating on formal lessons for longer than 5-10 minutes at a time were spending 20-30 minutes really concentrating on building with LEGO". (Tom's report, Summer 2001)

As told by his special class teacher, David's story captures this remarkable connection of the less able children as labelled by the existing system with this type of learning:

> Last October David (a 13 yr old) announced to other teachers and myself that he did not want to attend school anymore. Years of failure allied to a poor self-esteem had resulted in a very unhappy child. I introduced David to the Lego Robotics and the results were dramatic. Whilst the rest of the boys were learning basic building principles, David constructed a crane on his own initiative. He went down to a local building site at Dublin City University and asked one of the workers there to tell him about the crane. David did a sketch of it - this activity done by a boy who up to this, was very reluctant to do any school - related work at home. He came into school the following day full of excitement talking about pulleys/gear wheels, counter weights and couldn't wait to adapt these to his model. David displayed his completed model around the school. With this boost to his self-esteem, David became more sociable, confident and his attendance and punctuality at school improved dramatically. He was called on regularly to assist boys with Lego construction in the mainstream class and in his own class. His reading improved as he wanted to learn to read all the programming words and the names of the Lego parts. When asked why he was now happy in school he revealed, "I used to get into trouble but now I don't because of the Lego. It's keeping me happy and giving me a lot of ideas to think about". (John's Report Summer 2001)

David, although now moved to second level school, stills returns to his primary school every Wednesday as he finishes school at lunchtime. He acts as a consultant for the teachers and students working with computational materials. This is a remarkable turnabout in events for a young boy who had previously decided to drop out of school because he considered himself to be a 'failure' and is now regarded in such high esteem by the other boys and the teachers in the school.

> Teachers in other project schools had similar experiences, as consultants began to emerge who previously had not distinguished themselves in the traditional classroom. In one classroom, one of these building consultants was
>
> a quite unassuming child with a mild reading difficulty who really came into his own and grew in self-esteem and confidence by the end of the year. Another child became the 'programming consultant'. Because this latter child was happier programming than building … a useful working arrangement developed with the other children who preferred building. (Joan B.'s report, Summer 2001)

It was evident that

> children became to be valued for different skills e.g., a "gofer" – good at finding the right piece, a "sharer" – willing to share a RCX/LEGO piece when asked, a "programmer" – good for helping program the RCX, a "builder" – good for getting motors attached to a model etc. Some children were good at several areas, others at one but they all contributed in their own way and were valued for their contribution". (Tom's report, Summer 2001)

Such experiences brought to mind the question posed by Papert and Turkle:

> Why is it that these children are now relating to what is going on in school and demonstrating abilities that were never evident prior to the beginning of the project? Is it that the computer, with its graphics, its sounds, its text, and its animation, can provide a port of entry for people whose chief ways of relating to the world are through movement, intuition, and visual impression.(Papert & Turkle, 1990)

Can this explain why in so many classrooms teachers were surprised by the children who "came into their own" when this alternate way of thinking and working was introduced into the classroom? Children who had been labelled as "less academically able", needing "learning support" and even some who were in "special learning resource classrooms", began to emerge and demonstrate evidence of latent ability that never before had surfaced in the classroom. Clearly, these children had been denied their rightful opportunity to participate fully as traditional school culture had failed to acknowledge their innate ways of thinking.

These examples from teachers' classroom experiences represent EM's challenges to teachers' existing beliefs and attitudes about learning. By valuing the teachers' experiences and continually encouraging them to reflect and discuss their observations, EM enabled them to develop appreciation and understanding of other learning styles and ways of knowing. It has helped these teachers begin to understand that in our educational system to date, "Formal thinking, defined as synonymous with logical thinking, has been given a privileged status that can be challenged only by developing a respectful understanding of other styles"(Papert & Turkle, 1990).

The support structures EM developed (e.g., workshop format of building activity followed by reflective discussions; group meetings; classroom visits) sustained this validation of classroom experiences, enabling teachers to continue to collaborate, reflect and critically evaluate on their own learning and what was happening within their classrooms. As a result, many of the teachers have begun to question the content of existing school culture and its definition of success, intelligence, and achievement. .

### *Opening the door to 'formal systems'*

Papert and Turkle (1990) claim that "the conventional route into formal systems, through the manipulation of abstract symbols, closes doors that the computer can open" (p.18). The computational materials brought prolific evidence of "dealing with the world of formal systems" in all EM classrooms as children and teachers grappled with concepts and ideas that they otherwise would not have accessed. Across the project classrooms there have been countless examples illustrating that "the computer ...can make the abstract concrete; it can bring formality down-to-earth." (Papert & Turkle, 1990 p.2). These experiences were instrumental in sustaining teachers' interest in continuing to work with these materials. They also helped them quell their nagging doubts that they were neglecting "the curriculum" because they were spending so much time working with these computational materials.

For example, normally children of about eleven years ($5^{th}$ class) in mainstream mathematics are exposed to concepts of ratio and also the relationship between distance, speed and time. As these concepts usually are presented in a disembodied context, 11-year-olds generally don't engage with these concepts in any depth. Consequently the children usually memorise the rules of the required algorithm and their understanding goes no deeper than superficial manipulation of abstract symbols. However at one of the group meetings one of the teachers described his experiences when three groups of children tried to build models, which would measure:

- distance (a model that could calculate how far it had travelled as speed and length of time was varied)
- speed (how fast a model was travelling over a specified distance or for a specified time)
- time (how long it took for a model to travel over a variable distance at a variable speed)

They engaged with this task for several weeks, building various models and with each iteration, coming closer to understanding the complex relationships among distance, speed and time. They could build, program, try, and test in a concrete way whether the model was in fact measuring what it was intended to. The classroom groups collaborated constantly; teacher and children all tied themselves in countless knots trying to unravel the complex relationships of these abstract notions of distance, speed and time. Such in-depth exploration confirmed for the teacher that this way of working was more powerful and meaningful than traditional transmissive methods: it would develop children's understandings of mathematical concepts and relationships in ways that would have been impossible had the computational materials not opened the door to exploration and understanding.

Similarly, when children are trying to build a model that requires more torque and less speed, they are frequently confronted with the idea of gearing and gear ratio. A six year old girl explained to her teacher that she had to slow down the woodcutter model she was building so he wouldn't knock down Red Riding Hood because the motors were working too fast. When the teacher asked her to demonstrate what she meant she quickly showed her the gearing mechanism she had constructed while confidently telling her that

> 'I used an eight-toothed gear on the motor to turn a twenty-four- toothed gear which would make the woodcutter go three times more slowly because the small gear would have to turn three times to make the big gear turn once. This would make the woodcutter go more slowly and he would be more powerful as well.' (Observation Field notes, May 2001)

Not only could this child explain ratio, but she also had a very clear, practical understanding of the relationship between speed and torque. This is a clear example of situated knowledge. This young child had a clear understanding of quite complex concepts because she had come to understand them through developing her own projects using computationally powerful expressive materials in an environment, which encourages exploration and reflection. If the concepts had been presented to her in decontextualised form, it is debatable whether this child would have been able formally to represent the ratio of eight to 24, or be able to say that three multiplied by eight is equal to 24. But in the immersive learning experience, she has demonstrated that she is capable of understanding complex ideas, and is able to articulate her understandings of these. She is building conceptual understandings of powerful ideas that she will be able to represent later in formal and abstract ways.

Besides the manipulation of abstract symbols, the building of the models led the children and teachers to discussions confronting issues that perhaps would not otherwise have been conceived. In one classroom, when they were building models to represent human and animal forms and behaviours, some of the issues under discussion included:

- What behaviours of animals could be recreated in the models?
- What features and behaviours were essential to represent different creatures?
- If a horse had wheels, could it still be a horse?
- What would be the difference between the model of a cat and that of a horse?
- When trying to build a model, what is possible and what is not?
- When we decided that something was impossible. Was that because the technology was limited, or because our knowledge of the technology was limited or because it was just too much trouble? (Observation field notes November 2000)

In another classroom, children who were diagnosed as needing extra learning support used the Mindstorms materials, their digital camera, and the programming environment of Microworlds, to construct models and animations to tell stories that were important in their lives. For example, they explored issues relating to peer pressure and bullying (Observation Field notes April 2002). Using computational materials, these children who are do not have an "acceptable proficiency level" in the traditionally highly valued skills of reading and writing, can confront important issues in their own lives and are able to articulate, express and make sense of these issues which they were unable to do using traditional media.

As a result of their classroom experiences, EM teachers began to realise that once learners enter a world that uses a variety of computational materials for expression and meaning making, children who had once been denied a voice, found new ways to express themselves in imaginative and innovative ways. In addition, they were able to access ideas and concepts in a concrete way, thereby gaining complex understandings of issues long assumed to be beyond their comprehension.

### *The importance of discussion*

In traditional schooling, children spend most of their time listening to the teacher talk. However, when working with the computational materials in their classrooms, all the teachers remarked that the reverse was true. One teacher, in particular captures this increase in discussions, commenting that "communication skills were developed, as the children worked mostly in groups, and there were constant discussions about strategy and planning, and problem-solving as problems continually cropped up". (Conor's report, Summer 2001)

At their workshop, the teachers had realised the benefits and opportunities talking freely with one another. They could share ideas and expertise with one another and the discussions helped them to reflect on their learning process. So, building on their own experiences of interacting and talking with one another, the teachers encouraged the children to work in the same way. As one teacher explained:

> I held a discussion session at the end of each Lego session... each group spoke about what they had built, the problems they had encountered and about what they had learned. The rest of the children asked questions or made comments. These sessions developed later and the children used them to ask the class for ideas or for help in solving problems. The discussion sessions were also very useful for the final project [the end of year exhibition], as all the children knew what was going on in each group and could speak about each model at the exhibition...There were a few children that did not want to speak at the beginning of the year. They gradually developed the confidence to speak in front of their group, then in front of their own class and later in front of other classes. (Eimear's report, Summer 2001)

Teachers observed that when children were talking about their models, their creativity, imagination and understanding shone through. One of the teachers overheard a woman at the final exhibition commenting that "sometimes from looking at their models you'd never realise how much they know and understand....a lot of it is in their heads, you only realise it when they talk to you about their work". Many people made similar observations, highlighting for the teachers the inadequacy of the standardised testing used in many schools to categorise children and perhaps condemn them to a life of unfulfilled potential.

### ***Working in Groups***

Reflecting on their classroom experience, all of the teachers commented that an ethos of collaboration rather than of competitiveness developed within classrooms. One teacher commented that the project "encouraged the teacher to involve the class in *true* group work, by that I mean that the children are not merely sitting in groups but really contributing together to a goal where each contribution affects the next and the outcome" (Ruth's report, Summer 2001).

For example in one classroom

> two boys were the first to grasp the gearing concepts and helped many of the other groups to build models with gears. The children became used to helping each other. They learned not to be afraid to ask for help or to give help if they knew the answer to something. They learned problem-solving skills. They acquired the self-esteem to attack problems and tasks and not to be afraid of them" (Eimear's report, Summer 2001)

Another teacher remarked that this ethos,"transferred across to other areas...where children went around helping others with problems."(Tom's, report Summer 2001).

*Figure 2: Working together – "I think this goes about here"*

However working in groups also had its downsides, as there was sometimes a lot of confrontation and conflict.

*Figure 3: Difficult negotiation*

Indeed, this point was highlighted at our first end of year event for all the schools on 16th April 2000. A number of children from each of the schools addressed the audience about the most important thing they had learned during the year working with the project. When one young girl related that what she had learned was how difficult it was to work with others, a huge number of the audience nodded their heads in agreement. This is not sometime related to primary school children exclusively, as Martin (1994) who was also using expressive computational materials in a constructionist environment with third-level students states that "many students found that getting along with their team-mates to be one of the most challenging aspects of the whole project" (Martin,1994, p.59).

During the teacher workshops the teachers themselves also found it easier to work with some individuals rather than others. They realised that working in groups was often difficult. This prompted the teachers to reflect on how they could learn from these experiences and perhaps investigate different ways of promoting interaction between their students. As one teacher commented:

> For me I would like to develop better strategies for implementing group work with the class and to develop 'conflict resolution' skills in the boys. I started to use "Circle Time" with the boys and this may be an entry into sorting out some of my difficulties (Tom's report, Summer 2001).

### ***Mixed-age groupings/Experienced and inexperienced learners***

In selecting the teachers for the project we had tried to ensure that there was a range of teaching experience and comfort levels using digital technologies among the teachers in the group. By doing this we had hoped to create an environment similar to that of the Samba school where according to Papert, "Members ... range in age ...and in ability from novice to professional . But they dance together and as they dance everyone is learning and teaching as well as dancing" (Papert 1980, p.178).

Just as in the Samba school described by Papert, EM's less experienced learners could learn naturally alongside their more experienced colleagues. For the same reasons we had asked that the teachers working within each school would work with children from different grade levels. In the larger schools this meant that one teacher may have been teaching eight- and nine-year olds in one grade level while the other teacher took the eleven- and twelve-year olds at another grade level. Working in this way the teachers could share experiences. The teachers thought that the older children could help out with when the younger children had difficulties. Contrary to their expectations, what began to emerge was that age was no indicator of how children could use these materials. Nor did the teacher have all the answers to the problems the children were trying to solve. In fact, it was quite often the case that a younger child would help an older child sort out their programming or building problem.

As they gained more experience with the computational materials, teachers saw the benefits of children of mixed ages working together. The small rural schools were now seen as having a decided advantage as they had a wide age range in each of their classrooms. Several of the mainstream schools tried to facilitate this cross-fertilisation between age groupings within the constraints of the existing school organisation. In one of the inner-city disadvantaged schools, the principal reorganised the physical placing of the different class groupings, so the two project teachers were located beside each other on the top corridor as well as being adjacent to the computer room. In this configuration, the teachers and children could use both classrooms as well as the computer room to organise collaborative sessions. They even rearranged the computers around the walls of the room to provide a large open working space ideal for building activity and multiple group work.

The three teachers in another school also teamed up to work together with the special class (aged 9-13 years) and the mainstream fourth class (aged 9 and 10 years) working on a joint project (See Seán case study).

*Figure 4: Collaborative project based learning in action*

In the large suburban school, the EM teachers could not physically work together due to the school's policy of locating classes of children of the same grade level together in a particular part of the building. However, these teachers did encourage the children from the different grade levels to regularly visit each other's classrooms and talk about their projects as they were in progress: "The children learned a lot from showing their models to other classes... and also from seeing the models from other classes... putting what they saw into practice with their own models" (Eimear's report, Summer 2001).

In another school, the teachers managed to work together occasionally by timetabling their building sessions in the school's general-purpose room that was big enough to accommodate both classes. On other occasions, if the senior class children ran into difficulties with building or programming, they sent for the younger consultants from the other participating class in the project to help them out.

### *Evaluating 'Hard Fun'*

Caught as they were in the state system of education, the teachers had to juggle between getting the prescribed curriculum covered and engaging with project work using the computational materials. To cope with this conflict most of the teachers had definite days that they engaged in project work. These sessions were not timetabled like normal class periods but took place over a number of hours. The teachers observed that children who were normally poor school attendees came to school more regularly on project days. Presented with this fact the teachers were challenged to examine the existing curriculum and methodology. They began asking themselves why are these children who normally do not attend school, are labelled "weak" or who are not usually engaged by the normal school curriculum, now embracing this style of learning? Children in other classes envy the children who are working with the computational materials and are looking forward to the time when they can work in this way. In the school where the special class is involved in the project, there have been quite a number of applications from other children to become a member of the special class!—thereby reversing the special class's traditional standing as a place nobody wanted to be. Many teachers were baffled by these developments, as they all agreed that this type of learning is often difficult and requires persistence and concentration.

Using the traditional means that schools generally have relied on, it is difficult to assess just what, and how much, these children are now learning when working with expressive computational materials.In fact, one of the teachers in her report stated that

> Grabe and Grabe (2001) point out that higher-order thinking involves mental behaviours that are complex, effortful, self-regulated and judgemental. It is clear to me, while observing the children working with Lego materials that these behaviours are involved and that higher-order thinking in the form of problem solving and critical thinking are ongoing far more so than when they are engaged in ordinary school work. It is difficult however, to assess the extent of the development of these skills (Ursula Hearne, Teacher report, Summer 2001).

Only by engaging in ethnographic longitudinal studies like the Empowering Minds project can begin to expand an understanding of what being digital in learning, can be, and develop a language to describe it. Through their experience and involvement with the project, these teachers are beginning to appreciate the need for alternate learning values.

### *Learning as an equitable shared experience*

When using the computational materials and adopting the Atelier-style of working with the children in their classrooms, the teachers began to redefine their traditional roles: they became co-learners with their students.

*Figure 5: Children and teacher discussing a problem*

The relationship between teacher and learner became a more equitable, shared experience with both involved and participating in the learning process together. The teachers commented frequently that their relationship with the children changed, as children became partners in learning and were supports to one another. Most interaction took place between children, not predominantly between teacher and children.

The teachers attributed this shift in interactions to the fact that the children

> quickly came to see that the teacher, the fount of all knowledge, had feet of clay. At first all problems were directed at me for a solution. Soon the boys came to realise that a) my solution did not work b) their solutions were just as good as teachers or c) that teacher was, like them, stumped and could offer no real help.(Tom's Report, Summer 2001)

Another teacher echoed this sentiment as she felt her role changed to that of facilitator. She explained that she

> was definitely no expert in the area and the children knew not to rely on me totally for help. The most I could do was encourage, probe and throw out certain suggestions for them to try. They therefore began to rely more on each other for help and support. (Ruth's Report, Summer 2001)

Certain children emerged, as having particularly useful skills and these were not always those who were considered "the most able" or traditionally "academic" children.

Some children had difficulty adapting to the new learning environment and were distressed by the shift in their relationships with their teachers. Some became impatient and even frustrated and wanted a return to the established system that they were comfortable with. “Some children became very annoyed when I would not give them the solution to a problem straight away.” (Eimear’s Report, Summer 2001) One of the teachers describes how these children had difficulty in coping in his classroom

> Some children found this “new” way of learning very difficult to accept and even up to this point are still approaching the teachers as if we have the answers to their particular problems either in our heads, or in a book somewhere in our desks. These pupils are disappointed when we can’t tell them the answers, and sometimes may even resent that they have to go and explore to find the answers themselves. It seems they are so immersed in traditional methods of teaching-learning, where a question is posed, and there is one correct answer expected of them in a short space of time, that they have still not come to terms with open-ended problems in which they are expected to decide on their own direction and explore it. (Conor’s Report, Summer 2001)

### *Immersive engagement*

All the teachers reported that when it came to playtime, lunch or even going home time, children very often would choose to forego the playtime, or stay behind after school to try to finish the model they were working on. Children have also come in during Christmas vacation to get ready for the Young Scientist Exhibition—quite an unusual response to most school-related activity. One teacher was so impressed and encouraged by her students’ enthusiasm that she sent me the following mail:

> To:"DeirdreButler"<dbutler@media.mit.edu>
> Subject:Re:Legostand
> Date: Mon, 30 Dec 2002 11:56:22 -0000
>
> Hi Deirdre,
>
> Happy New Year. The Lego area looks ideal, plenty of display area for models and posters.We're in school on Thursday next, 2nd, to put the finishing touches to models etc. I think it's amazing that I had to limit the numbers coming in I had so many who wanted to come. I can't imagine that happening for any other type of project.
>
> Hannah

Work with the computational materials seemed to take on a life of its own as children made modifications in response, perhaps, to someone’s idea, or to something they were trying to do that had an unexpected result. Projects seemed to take on that “never-quite-done” sense as the children continually wanted to change them or add something in order to “make it better.” No external force was necessary to compel them to continue as they were so totally immersed in the goal they had set themselves.

The children weren't alone in their reactions to this new learning experience. At the teacher workshops, I typically had to shake the keys and announce that I was going to lunch and if anyone wanted to stay, they could lock up and follow us. Most reluctantly came along, but many of them rushed through lunch in order to get back to the lab to continue work on their project. Teachers who organised informational workshops for teachers from other schools (e.g., West Dublin Education Centre Computer Users group) commented that they had the same experience: the visiting teachers were so engrossed in making their models that they did not want the usual sought-after coffee break—or even, in some cases, want to go home.

. *Figure 6: Home-time !! Just let me make one more adjustment!!!*

As a result of their unique backgrounds and learning styles as well as their individual school contexts, teachers differed in their methods of appropriating the computational materials and Constructionist approach to learning. In this section, I have attempted to illustrate the ways Empowering Minds structured an environment that challenged these teachers' beliefs and assumptions about learning. They made the daily reality of their practice into their "object to think with" as they began to reflect on the learning experiences they witnessed or were a part of with their students.

They found difficult the challenges of this way of working and the questions that arose as a result. Indeed, many EM teachers have commented that the time they have spent in the group probably has been their most frustrating learning experience ever—and their best. They make their conflicts clear in these sample comments:

I benefited. I really enjoyed the time spent at the project. It was one of the first times I felt that the boys were really learning, really interested in what they were doing. I have really enjoyed this year. It has sometimes been frustrating and I felt that I was being pulled in all directions at once... but it has re-awakened the joy I used to have teaching. ... ...Thanks for the opportunity of taking part in this project. We have all really enjoyed it and learned so much about ourselves through it. (Tom's Report, Summer 2001)

After completing the summer course last August I was very excited and was really looking forward to beginning work with my class. This enthusiasm did not fade as the year went on. I found the year to be very interesting and stimulating both for the children involved and my self. I learned so much from the year; not just practical Lego/ICT skills but I also learned a lot about children. I learned that children should never be held back, that there is no limit to the amount they can learn and teach others... I learned to be a facilitator. I learned to accept a higher noise level than before. We were very proud of the work done during the year. Even though sometimes I vowed that I couldn't continue next year as it was hard work the good times by far outweighed the bad! ...I found this year a very rewarding and interesting one. I believe that the children benefited immensely from taking part in the project, and learned a lot...... I am looking forward to continuing the project and feel lucky to have been a part of it for the past year. (Eimear's Report, Summer 2001)

As a teacher I find I am still on a voyage of self-discovery in my teaching in this project. I find new problems, challenges and strengths emerging as I progress through this work and look forward to my next class and the challenges they will present me with (Cliff's Report Summer 2001).

# APPENDIX G

## *The Mexican High Priest*

Starting with no fixed ideas as to what our final project would be, the group (Seán, Donal, Tom and Deirdre) engaged wholeheartedly in trying to understand what made the Mexico of today. We visited the National Anthropological Museum often to find out more about this culture, which so different from our own. We also talked with the Mexican teachers at length, about their folklore and mythology. Realising our deep interest one of the Mexican teachers drove us to two specialist bookstores where she thought we might find some literature in English that would help us. Unfortunately all the books were in Spanish. However we bought some beautifully illustrated children's books and spent many evenings with Jaime from Colombia patiently translating these stories for us. To immerse ourselves in the Mexican culture we packed in many visits to historical Mexican sites (e.g., Zocalo Square; Bosque de Chapultepec- the residence of the Aztec emperors; Templo Mayor, the ancient Aztecs' principal temple complex; Coyoacán: Pirámide de Cuicuilco; Xochimilco; Tepozlán). Everywhere we went we tried to learn as much as possible taking photographs and video footage, looking, listening and asking questions of the people we met. During our visit to the Sun and Moon Pyramids at Teotihuacán ("the place were men become Gods") we were lucky to have a very knowledgeable Indian guide who revealed to us many wonderful secrets of these ingenious ancient people.

When it came to deciding what we would construct for our project it was difficult to decide what to focus on as a starting point. After much discussion the things that had the most profound impact on us began to surface, including:

- the dance we had seen many of the indigenous people perform with such reference in so many of the places we visited
- the evidence of the power of the ancient gods and their sacredness to the people
- the fascinating strong colourful patterns evident in all the craft work.

*Figure 1: Mexican Indians dancing a traditional dance in Zocalo Square, Mexico*

These elements helped us form an idea of what our project was to be. We decided to design and construct a high priest dressed in colourful clothing depicting the most powerful of the gods, the plumed serpent Quetzalcoatl, performing an ancient dance ritual. How we went about this seemed to flow naturally. Seán who has great experience of DIY and is gifted working with his hands, crafted the head from a polystyrene ball using a simple craft knife. This was adorned by myself with pieces of felt, wool etc., to resemble a dignified high priest.

*Figure 2: Model of the plumed serpent Quetzalcoatl*

*Figure 3: Sculpture of plumed serpent Quetzalcoatl at Teotihuacán, Mexican*

Meanwhile Donal and Tom were busy constructing the frame for the body using Lego materials. We had discussed how many crickets and sensors we thought our high priest might need to perform his dance and these were incorporated into the framework for the body. The outer garments were proving to be a bit difficult to make when one of the other teachers in the group came to our rescue. Ursula had lots of experience making clothes so was quickly able to show us how to cut out a pattern for a long flowing robe which would cover our Lego framework.

*Figure4: First Prototype of Framework for High Priest model*

*Figure 5: Revised Framework for High Priest model incorporating crickets, sensors and motors*

While I continued to make the robe from alternate strips of red and yellow tissue paper (there was no fabric available) she volunteered to make and decorate the large front central panel of the robe. Referring to photographs we had taken on our trips and a child's history book that one of the Mexican teachers had given to us, we decided on the patterns (symbols of the wind, the rain, the earth and the sun) Ursula should incorporate into the front panel. Donal, Seán and Tom programmed and tested the skeleton framework to make basic movements using simple procedures programmed with cricket logo. Before deciding on the sequence of the dance, we reviewed the video recordings of the various dancers we had seen on our trips and based the movements of our priest God's dance on the common basic movements in these dances.

The programming took some time as it became complex requiring signals to be sent from the bottom cricket (which was controlling the bottom motors responsible for moving the model forward and back) to the top cricket (which was controlling the motors responsible for moving the model's upper body). Once we were happy with the dance sequence we put the robes and front panel on and fixed the head in place. This caused other problems as the head was too heavy for the upper part of the framework to lift so it had be rebuilt with extra torque being provided by a different arrangement of gears.

*Table 1: Logo procedures for Mexican God's dance sequence*

| Mexican God Dance programme written using Cricket Logo | | |
|---|---|---|
| to go<br>dance<br>send 1<br>bow<br>loop [waituntil [newir?]<br>if ir = 2 [ twist ]]<br>end | to forback<br>ab,<br>thisway<br>onfor 20<br>rd<br>onfor 20<br>end | to twist<br>repeat 2 [forback wait 5<br>right<br>wait 5<br>left]<br>end |
| | to left<br>ab,<br>thisway<br>a,<br>rd<br>ab,<br>onfor 40<br>end | to bow<br>loop [waituntil [newir?]<br>if ir = 1 [nod]]<br>end |
| to dance<br>setpower 8<br>repeat 2 [forback wait 5<br>right<br>wait 5<br>left]<br>end | to right<br>ab,<br>thatway<br>a,<br>rd<br>ab,<br>onfor 40<br>end | to nod<br>a, setpower 2<br>thisway<br>a, on<br>repeat 2 [ setpower 2 if sensorb [wait 20 rd]<br>if sensora [setpower 7 wait 15 rd]]<br>a, off<br>send 2<br>end |

If someone just saw this model perform its dance they would not appreciate the rich learning and intricate group dynamics that had occurred in order to construct it. They could not imagine the experiences that informed its construction. Most people would perhaps just be mildly interested in its construction and its ability to perform a rather slow and dignified ceremonial 'dance' routine. However this model encapsulates a multitude of experiences and it was the culmination of long hours of collaborative research and dialogue. For the group who built it, the model symbolises the fusion of their experiences of the ancient Mexican culture with the digital technologies of the twenty-first century. When they see video clips or a pictures of this model all of the group agree that it is not just the physical construction of the model that is remembered but also a host of experiences that informed its construction.

*Figure 6: Creating the headdress for the High Priest model*

*Figure 7: Creating the outer garments for the High Priest model*

*Figure 8: One of the teachers checking out the programming of the high priest model*

*Figure 9: The High Priest dressed in the robes of the plumed serpent Quetzalcoatl*

With the construction is interwove the stories we heard, our visits to the ancient monuments, the people we met and talked with, the problems we had programming the crickets to make it dance like the warriors we saw in the square at Zocalo and much more. It is a truly multi-layered experience that conjures up different images and experiences for the individuals who collaborated in its construction rather than a sterile encounter with a decontextualised piece of digital technology It was this experience that lead Seán to an understanding of the deep personal connections with learning people can have when working in this constructionist way with expressive computational materials. Consequently he is more aware of looking beyond the artefact his students create and is very conscious of the process that has culminated in this external object. This story illustrates beautifully that reviewing the 'product' is not sufficient to evaluate learning what is of ultimate importance is understanding the 'process' involved in the construction of the artefact.

# Appendix H

(The text and pictures that follows has been taken directly from the teacher and children's description of this project as published on their school web-site)

## *Earthquake in Springfield*

### How the Project Developed

When we began planning what we would do for the Robo Show in June we had quite a few discussions before any building began. After seeking ideas, the one that was eventually settled on was to make a kind of obstacle course and then each of four groups would design models to negotiate the obstacles. The initial idea was that we would quickly come up with a few ideas for obstacles, build them, and then each group could get on with the real task of building the vehicles to tackle the obstacles.
However, as the discussion unfolded, pupils came up with many ideas for obstacles, and the obstacles began to take on a 'life of their own'. They wanted to incorporate light sensors and touch sensors, etc. into the obstacles, so that they could be activated by the vehicle, as it approached.

They became so engrossed in the ideas for the obstacles that pretty soon the obstacles had taken on as much importance as the vehicles themselves. Eventually one pupil made the suggestion that, instead of having all four groups building vehicles, perhaps two groups should design the obstacles, and two groups design the vehicles. Surprisingly, there was great enthusiasm for this idea and no difficulty in getting volunteers for these groups. The next day's discussion had more ideas for obstacles but a new problem emerged. Now the obstacles and the vehicles would be being built at the same time. How would the vehicle-builders design their vehicles for obstacles that were not built yet? For example, one proposed obstacle was to be a ramp that would be hinged in the centre, so that when the vehicle climbed one side and the centre of gravity passed over the fulcrum, the ramp would tilt down in the opposite direction to allow the vehicle move off. The size of the ramp would have implications for the width and length of the vehicles. We now had a classic chicken and egg situation - should the size of the vehicles dictate the size of the obstacles or vice-versa!!

Another problem was that if several obstacles were designed, each demanding some different reaction from the vehicle, there might be problems with not having enough sensor ports. One proposed solution was that, with only two vehicles to be built, perhaps each vehicle could have two RCX's, which could talk to each other, and therefore double the number of sensors available!!!
Was this realistic?? No-one knew. It would also have further implications for vehicle size, including height. They seemed to agree that two RCX's directly over each other, with just enough space between them for access to the lower one was the best arrangement. But would two RCX's communicate with each other if the infra-red windows were directly above each other?

Pupils also proposed that some members of the Obstacle Groups would swap with members of the Vehicle groups on some days to help out the other group and to help co-ordinate the two parts of the project. Would this work?

They also decided to set out at the start what maximum and minimum length /width /height the vehicles should be. After much discussion and measurement figures were agreed. Once construction began, these figures began to change as other considerations

came into play. However, the principle that the models had to be built or re-designed with reference to the obstacles and vice-versa, was retained.
Sometimes the imperatives of designing the vehicle forced changes to the obstacles whereas on other occasions the reverse was true. There were many discussions on these issues but generally each group was willing to change to accommodate the other where possible. Often, though, changes that were made had knock-on effects later. They soon realised that the two groups designing obstacles had to come together so that the obstacles demanded different reactions and capabilities from the models, and that the sum of the demands, e.g. the number of sensors demanded, was possible to achieve.

Many of the ideas which came up were very interesting - such as the one where the vehicle was to drive into a giant Pyramid of Egypt and would then have to locate the secret doorway to get out again - but many were way outside the realm of the possible.

There was also the problem that the ideas were so diverse and there were just too many of them. Eventually it was agreed to have a single theme and that all obstacles would fit into that theme and this would help to tie the project together. Most suggestions for themes centred on warfare, disasters, and such like. After much discussion the theme of a city hit by an earthquake was agreed.
The obstacles would now fit in with events that might result from damage caused by an earthquake. As construction began we needed to locate the city and began to look for a name. Springfield, the hometown of the Simpsons, somehow became the chosen city. Now the nature of the obstacles began to take shape.

There would be a bridge, which had been damaged by the earthquake. There would be a number of street junctions and the vehicles would have to select the correct route. But one question remained unanswered. Where were these vehicles trying to go and why? We needed a story on which to hang whole project. More discussion.
A story began to emerge. The earthquake had damaged the nuclear power station. There was some dangerous nuclear waste at the power station. For the safety of the city it had to be transported to safety and the trucks transporting it had to negotiate their way across the city. It was decided that the nuclear waste would be dumped into a disused mine at the other side of town.

As the size of the area required became an issue and as it became clear that there was not much to be gained by having two groups designing vehicles to get past the same obstacles it was decided to co-operate. One vehicle would transport the waste over the first part of the journey and then transfer it to the second vehicle, which would transport it for the remainder of the journey.

Next came the idea of writing a script for the story and when ideas had been drafted it was decided to turn it into a news bulletin for the local television station. The story was allocated to reporters at several locations around the city. The reports were linked by a newscaster in the studio. These reports were recorded and assembled into a PowerPoint presentation to accompany the project.

The pupils had taken on a concept, which was to set problems for themselves and then to solve those problems. As they became involved in the problem-setting, the problems became as much 'alive' as the vehicles. Also the problem-setters saw their task as being equally as complex as that of the problem-solvers. A surprising aspect of the project was that those who were setting the problems - the obstacle builders - recognised that success would be achieved, not by ensuring that models could not overcome their obstacles, but by ensuring that they could be overcome - but only with good design.

## *Springfield Project Summary*
## *S.O.S. (Save Our Springfield)*

We decided to build an obstacle course because we wanted to set up problems for ourselves to solve. We created a story around the obstacle course. The background to the story is the town of Springfield, home town of the Simpsons.
There has been an earthquake and many of the buildings have been damaged. There is an emergency at the Isotope Nuclear Power Station. The station can no longer safely hold the nuclear waste. The waste must be transported to a disused mine at the other side of the town.

A truck must collect the nuclear waste from the power station. The waste is loaded onto the truck by conveyor belt. The truck then heads off towards the bridge. But the bridge is raised. The truck sends a signal to the bridge and this lowers the bridge in time for the truck to cross. Then there is a fallen building blocking the street.
The first truck cannot get past and another truck is waiting at the other side. The first truck passes the nuclear waste to the waiting truck. The second truck then comes to a junction where it must choose from three streets. If it goes left down Burns Boulevard Springfield Elementary School has collapsed into the street and the street is blocked. If it goes right, down Milhouse Street, electric cables have snapped and there is a massive fire. The only route to the mine is straight ahead. When the truck reaches the mine it signals the mine and the gate opens. The truck drives in and empties the nuclear waste into the mine.

We built the first truck with a loader at the front. The container is delivered from the conveyor belt at the power station into the loader. The loader drops the container into a trailer behind the second truck.

The mine, the bridge and part of the power station are made of Lego. The other buildings in Springfield are made from cardboard. We made the school, the Town Hall, the power station, Moe's, the Quick-e-Mart.

We have also recorded a news bulletin from Clontubrid Network News (CNN), which reports from Springfield after the earthquake. There are reports from several locations throughout the city. The report has been prepared as a PowerPoint presentation, which runs with the models.

## *Springfield Earthquake Models*

These are the models or robots we built to tell the story of the earthquake in Springfield. We have some photos of the models and we describe how they worked and some of the problems we had with them.
The First Truck
The Second Truck
Conveyor Belt at Nuclear Power Station
The Bridge over the River Homer
Gate at the Mine

## *The First Truck*

The First Truck goes from side to side and finds its way along the road. It does this by following a black line. To follow the black line we used one light sensor. The light sensor can move up and down because the truck has to go up and down a slope when it comes to the bridge.

*This is the truck. It has two wheels at the back and runs on arms at the front. There is a light sensor at the front following the black line.*

The truck starts off with motor A running. This brings the light sensor over the black line. The light sensor is programmed to see the black line. When it sees the line it turns off motor A and turns on motor C for 0.3 seconds. It then turns off motor C and turns back on motor A. This takes the light sensor off the black line a little and then brings it back again. The truck moves zig-zag along the edge of the black line.

*This is the second light sensor. It is pointing to the left. It sees the lights on the Conveyor Belt and stops the truck in the right place.*

There is another light sensor on the truck. This one is pointing to the side and it will see the lights on the conveyor belt. When it sees the lights it sends a signal (the number 1) to the conveyor belt. The truck stops and the conveyor belt lets down an arm holding the conveyor belt. It turns on the belt and this drops the nuclear waste into the truck. Then it sends a signal to the truck (the number 2) and the truck is programmed to move on again when it gets this signal.

*This is the front of the truck. The arm on the left hits the touch sensor if it runs into the second truck. This stops the truck.*

*This is the bucket on the truck. The nuclear waste dropped into the bucket. We put on a sloping piece of Lego in case it didn't drop in the exact position. Then it would roll down into the bucket.*

When it starts again the truck sends a signal to the bridge (the number 3). The bridge is waiting for this signal. When the bridge gets the signal it comes down from the upright position. It has to be lowered before the truck gets there so that it can cross.

After the bridge the truck meets the Second Truck. When it reaches the Second Truck it is stopped by a touch sensor. Then the First Truck drops the nuclear waste into the other truck. A slow motor lifts the bucket containing the waste and it rolls into the second truck.

### *Problems:*

*Problem:* Trying to get the truck to stop in the right place when it came to the power station. Sometimes it was too far out from the conveyor belt and the waste missed the truck.
*Solution:* We found out that we could make it work by changing where the conveyor belt was. When we found the right place for the conveyor belt we marked it on the board and made sure every time that the conveyor belt was in that exact place.

*Problem*: Getting the truck to go over the bridge. When it was going up the bridge the light sensor was sticking in the ramp. When it was coming down the other side the light sensor was too high off the ground and was not finding the black line.
*Solution:* We put the light sensor on an axle which could go up and down as the truck went up or down the bridge. We put on two sliders to keep the light sensor off the ground and to make it move smoothly along the ground.

*Problem:* Getting the truck to stop when it hit the second truck, and getting it to unload the nuclear waste and getting it to send a signal.
*Solution:* We had antennae on the front. When one of these was bent back this released a touch sensor and this was programmed to stop the truck, unload and send the signal. We could never get it to work properly.
We had two touch sensors connected to one port and they were programmed to stop the truck when one was released. We discovered that this programme would not run unless the two sensors were released together. Most of the time this didn't happen. We

discovered that the program would work if we could get the touch sensor pressed instead of released. We put on a different touch sensor and an extra arm which would press it when the truck ran into the other truck. this was a little bit better.

*Group:* Shane, Robert, Deirdre, Roseanne, Ciarán.

## *The Second Truck*

*The Second Truck is in two parts. The front part has the motors, RCX, light sensor and antennae with touch sensor.*
*The second part has the small motor to tip the nuclear waste out of the trailer.*

What the Second Truck does is the truck waits until the First Truck elivers the nuclear waste and unloads it into the back of the Second Truck. Then when that is done, the First Truck will send a signal to the Second Truck.
The program on the Second Truck is waiting for the signal. At the start of this, it sends the message 5 to the Gate of the Mine. The Truck has to go through the gate of the mine. When the gate gets the signal it is programmed to open.
The Truck then pauses for 20 seconds to give the gate time to open. Then it starts the program to follow the black line. It turns on Motor A for 0.4 seconds. This takes the light sensor away from the black line. Then Motor A is turned off and Motor C comes on. This brings the truck back to the black line. When the light sensor sees the black line Motor C goes off and Motor A comes on again for 0.4 seconds. It keeps doing that the whole time.

*This is the front of the truck. The antennae are attached to a touch sensor. When they hit something and bend back the sensor is released and the truck stops. The elastic band makes the antennae spring back.*

The Second Truck will go through the gate following the black line. It hits the wall behind the gate. The antennae at the front hit the wall and they spring back. This releases a touch sensor. The sensor is programmed to turn everything off. Then when everything is turned off, it sends the message 6 to the Gate.
The gate is waiting for this signal and when it gets the signal it closes. The last thing the truck does is to start Motor B which tips out the nuclear waste from the trailer.

*This is the gearing on the truck. An 8-tooth gear on the motor connects to a 40-tooth gear. A 24-tooth gear on the same axle connects to another 40-tooth. This is about an 8:1 reduction.*

*This is the tipper on the trailer. A small motor (bottom on right) drives an 8-tooth gear and this connects to a 24-tooth gear on another axle. This lifts the arms where the nuclear waste is carried and tips it out into the mine.*

### *Problems:*

*Problem:* The signal from the First Truck didn't reach the RCX because it was facing away from the truck.
*Solution:* Instead we got the First Truck to send the signal to the Gate RCX because it was facing it. Then the Gate RCX sent back a signal to the Second Truck.

*Problem:* The gearing on the truck is not low enough and it travels too fast.
*Solution:* We didn't have time to change the gearing because we would have to rebuild the truck. We powered down the motors, we shortened the time moving away from the black line to 0.4 seconds each time and we also programmed the Second Truck to wait for 20 seconds to give the gate time enough to open.

*Problem:* The slow motor which unloads the nuclear waste is hard to fix on to the truck and sometimes it falls off.
*Solution:* We tried to build it in so that it stays in place and has enough power to turn the axle.

*Group:* Shane, Robert, Deirdre, Roseanne, Ciarán.

## *The Conveyor Belt at the Nuclear Power Station*

The Conveyor Belt is part of the Isotope Nuclear Power Station in Springfield. All the rest of the building is made from cardboard. The Conveyor Belt was built to remove the nuclear waste from the Isotope Power Station, where an earthquake has taken place.

*This is the Conveyor Belt. The motor on the right raises and lowers the belt. The motor on the top drives the belt. The RCX is facing the front to get and send signals.*

When the program starts running it turns on three lights and waits for a signal from Truck 1. The truck has a light sensor which will detect the lights and then stop exactly under the Conveyor Belt. It will send the signal 1 to the conveyor belt.

*This is the gearing on the conveyor belt. The motor is sitting on the top.*

When the conveyor belt gets this signal it turns on motor A, which lowers the conveyor belt. When it touches touch sensor 1, it turns off motor A and turns on motor C. Motor C turns the belt and carries the nuclear waste out over the truck. The nuclear waste falls into Truck 1. The Conveyor Belt stops turning (motor C is turned off). Then the Conveyor Belt is raised again. Motor A is turned on and reversed. It goes back up until it hits touch sensor 2 and stops (turns off A and on C). Then it sends signal 2 to Truck 1. The truck is programmed to move off again when it gets this signal.

*The three lights on the front of the Conveyor Belt are there to stop the truck. The light sensor on the truck sees these lights and to stop the truck.*

*When the arm of the conveyor belt was raised at the end of the programme it hit a touch sensor and this stopped the programme. The next time we turned it on the touch sensor was still pressed and it turned off straight away. This note was to remind us to move the arm a little bit waway from the touch sensor before we started it again.*

To build the Conveyor Belt, we used two motors, 1 RCX, 3 lights, 2 touch sensors and much more.

### Problems:

*Problem:* It was very hard to build because the gears keep slipping. That was because the motor was separated from the Conveyor Belt.
*Solution:* We braced the motor to the rest of the building.

*Problem:* We have to put the conveyor belt in exactly the right position or else the nuclear waste will not fall into the truck. If it is too far back the arm of the conveyor belt will not reach the truck. If it is too close to the truck the truck might hit the conveyor belt or get tangled in some of the leads.
*Solution:* When we found exactly the right place we marked the board and made sure the Conveyor Belt was exactly in this position every time.

*Problem:* If the back of the conveyor belt is touching sensor 2, when the program finishes the touch sensor is told to turn off every port and send message 2 to Truck 1. When the program starts again the next time it does this straight away, even though we don't want it to.
*Solution:* We put a note on it to remind us to move the conveyor belt a little bit away from the touch sensor before we start the program again.

*Group:* Jane, Laura, Sinéad, Sarah.

## <u>The Bridge over the River Homer</u>

The Bridge is built the same width as the road so that the model will fit on the bridge. On both sides of the bridge there are motors and gears. The motors are geared down so that the bridge will go down and up slower. The gearing is exactly the same on both sides so that the bridge will go up and down evenly. The gearing ratio is 25:1.

*This is the bridge from the front. It is half way up.*

*This is the bridge from the side. The bridge is lifted with pulleys and fishing line. When the bridge is being raised all the weight is on the top. We had to build it very strong. In the beginning the top kept breaking with the weight.*

We programmed the bridge so that when it gets the signal 3 from Truck 1, the bridge turns on motors A and C. This lowers the bridge. Then when it goes down as far as it can, it touches a touch sensor. The touch sensor is programmed to stop the motors and wait for about 70 seconds. This is to give the truck time to cross the bridge. Then it goes back up to where it was at the beginning and touches the touch sensor at the top. This touch sensor is programmed to turn off motors A and C.

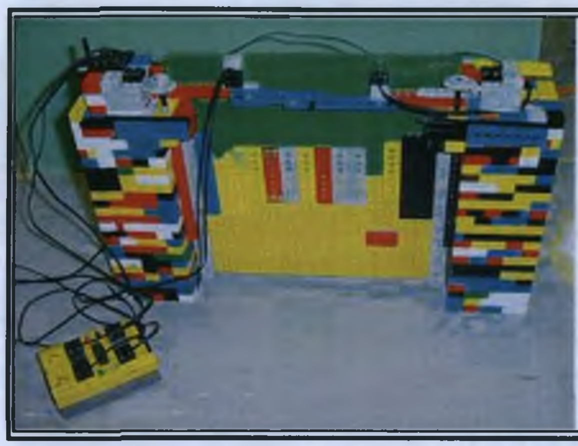
### *Problems:*

*Problem:* The programme did not work. Firmware went 3 times and we lost the programme each time.
*Solution:* Changed batteries in the RCX. Rechargeable batteries were part of the problem. They never seemed to last very long.
*Problem:* The touch sensor that was at the bottom of the bridge wouldn't work because we couldn't get it to fit anywhere where it wouldn't be in the way of bridge.
*Solution:* We put the touch sensor at the side and put a Lego person's head on the bridge. When the bridge came down the head hit the touch sensor and stopped the motors.
*Problem:* There was a gap at the back of the bridge to allow it to lift up. When the bridge was lowered the truck could not pass with the gap still there.
*Solution:* We had to find a way to close the gap when the bridge was down and to open it when the bridge was going up. We made a card flap and put an arm underneath to raise it and lower it as the bridge goes up and down. This arm is driven by a third motor, motor B. We geared it down to make it move slowly. The gearing ratio is 125:1. This motor is programmed to turn on for 6 seconds on the way up and on the way down. This works most of the time. Sometimes the truck still gets stuck at this flap.

*Bridge Group:* Sharon, Andrew, Ciarán and Ethan.

## The Gate at the Mine

The gate is opened by raising it up. The gate is supported by two piers and it slides between braces to keep it from swinging back and forth. There are two motors at the top, one at each side. Each motor is programmed the same to keep the bridge moving evenly on both sides.



*This is the Mine Gate. There are motors at the top on each side and a touch sensor on each side.*

The motors are attached to crown gears to change the direction of the drive. They lower and raise the gate with rack gears. There is a line of rack gears up each side of the gate. When the gate is raised high enough it hits a touch sensor which is programmed to stop it. When the gate is lowered almost to the ground it touches another touch sensor which is programmed to stop it.
Our gate is waiting for a signal form the Second Truck. We have two motors. When the signal is sent they will open until the touch sensor is pressed, then the gate stops. Then the truck follows the black line though the gate. When it gets to the back, the touch sensor is pressed. Then it sends another signal to our RCX to close the gate again until the second touch sensor is pressed.
Then the trailer, which is connected to the truck, lifts a scoop and drops the nuclear waste and Springfield is saved.

### Problems:

*Problem:* The gate kept slipping on the rack gears and wouldn't open. Sometimes one side worked and the other didn't and the gate leaned to one side.
*Solution:* We put braces down each side to keep the gate in position. We also put in pegs at the back to keep the rack gears pressed against the gear wheel so that the gear didn't slip. It was very hard to get the two motors in exactly the same position. The motors were at opposite sides and facing the middle. Because they were the opposite way round we couldn't match their positions exactly on each side. One was working better than the other.

*Problem:* We couldn't get suitable places to put the touch sensors so that the gate could press them at the top and bottom. The leads were in the way or else the sensors themselves were in the way of the truck. The gate was only just high enough and wide enough for the truck to fit through and even a touch sensor and a few bricks to hold it in place took up enough space.
*Solution:* Eventually we discovered that we could put both sensors at the top, one at each side. We put them on the supports and put bricks on the gate that would touch them. One brick was put at the top of the gate and it would touch the sensor when the

gate came down. The other brick was at the bottom of the gate and it would touch the second sensor when the gate was up. This solved the problem.

*This is the rack gear up the side of the gate.*

*This is the motor attached to the crown gear at the top of the gate. You can also see the touch sensor to stop the gate when it is raised.*

*Problem:* The gate had to get a signal from the Truck to run the program to open. It had to get another signal from the Truck to run the program to close. The first signal was sent when the Truck was in front of the gate and the second signal was sent when the Truck had passed the gate.
*Solution:* We had to try to find a place and direction for our RCX so that it could receive both signals.

*Group:* Adam, Paul, Owen, Jamie, Zephlin.

# Appendix I

(The text and pictures that follows has been taken directly from the teacher and children's description of this project as published on their school web-site)

## *The Break-In*

This project is based on a story called ***"It Wasn't Me"***, which we wrote for a short film which the class made before Christmas. We wrote a script, made a story-board, made a set and cast the film. Then we filmed it and we edited the film.
Then we decided to try to make Lego robots and programme them to act out part of the story. We built and decorated the house. When we got the robots working we filmed them acting out the story. We edited the film and put music to it. We called it ***"Who's in the House?"***

***This film is also part of our Mi World project. In this project we used this film as our idea of what life might be like in the future, when many things will be controlled by robots. We called it "Mi Future".***

This is the house with windows and doors and the owner inside.

In our project we have the Owner of the house; we have the Robber and we have two doors and a cabinet where the jewellery is kept. All these are controlled by RCXs that are programmed to work with each other.

## *The Story*

The Owner of the house leaves the house, and closes the door behind her. When she has left the Robber arrives and breaks into the house. He finds his way to where the jewellery is kept and manages to steal it. Then the Owner returns home to find the Robber in the house. When the Robber discovers that the Owner has arrived he makes his escape out the back door of the house.

## The Models

The Owner
The Robber
The Front Door
The Back Door
The Jewellery Cabinet
We also made doors, windows, curtains, pictures for the walls and furniture for the house.

This is the inside of the house with the owner in the background and the robber on the right. The owner returns and the robber begins to make his getaway.

### *The Owner*

#### *Building*

We started with the frame, which we built mostly of ordinary bricks and beams. Then we built the base out of beams. We put in a motor on each side and built them into the sides to make sure the motors stayed in place. We put in some flats to make the gearing easier. Then we started gearing. There is a 8-tooth gear on the motor and this is connected to a 40-tooth gear. On the same axle as the 40-tooth gear is an 8-tooth gear and this is connected to another 40-tooth gear. This axle also has the wheel on it. So we have a gear reduction of 5 X 5, which is 25 to 1. This makes the model move slowly and smoothly. The gears are the same on both sides. We built in the motors with flats and put sliders on the front. We made room for the RCX inside the model and left a gap at the front so that the RCX could send and receive signals.

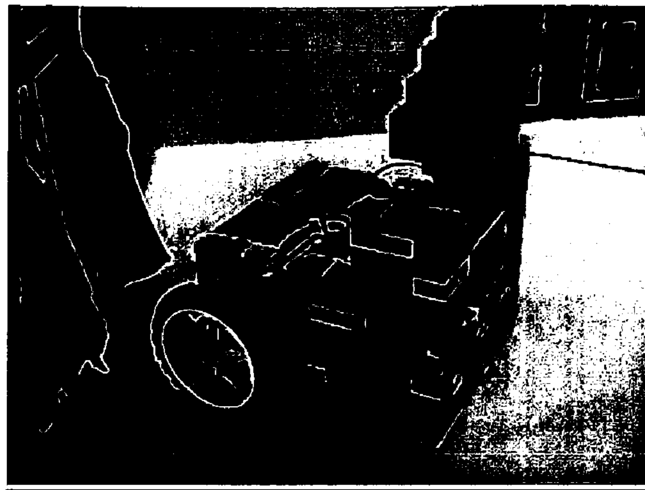
| | |
|---|---|
|  | The owner from behind.<br>She has eyes in the back of her head.<br>But even that is not enough. |

### *What it does*

The Owner leaves the house and signals to the door to open on its way out. Then it turns back to the door when it has gone outside, and signals to the door to close. It then turns around and moves off.
Later the Owner comes back to the house and signals for the door to open. When the door is open the Owner goes inside and turns back and signals the door to close. When the door is closed it turns in to look around the house.
It sees the Robber and sends the signal which gets the robber to leave.

### *Programming*

The Owner runs two programs, one for leaving the house and another for entering the house. For leaving the house the owner is programmed to send a signal to the RCX on the door. It sends No. 1. this is the signal for the door to open. The Owner then waits for 32 seconds, which is how long the door takes to open. The Owner then moves forward – Motors A & C are turned on. When the Owner passes through the door a light sensor on the side spots a light outside the door. This is programmed to stop the motors. Then it turns on one motor going forward and the other going backwards to turn the model around 180 degrees. This takes 8.5 seconds. It sends signal No. 2 to the door RCX and this closes the door. The Owner again is programmed to wait for the door to close. Then it turns another 180 degrees and moves off away from the house. For coming back into the house it does much the same thing until the door is closed. Then the Owner turns into the house (90 degrees), screams and sends the message that sends the robber out of the house. The message is No. 5.



The owner. Sideview.

### *Problems*

We had to make many changes since we started. The back and front of the model were not steady and kept breaking. We had to rebuild them and link the blocks into the side walls to make them stronger. The biggest problem was the programming. We had to send messages and measure how much time to wait for the door to open and measure how much time it would take to get past the door before it needed to turn.

The problem was that we were testing on the desk and the carpet of the classroom. But when the house was made we were running the models on timber, which had been painted. The model ran slower on this and sometimes it slipped. We had to keep changing the times.

By: *Laura, Deirdre, Máire Eilish, Simon, Niall and Andrew, Ciara.*

## ***The Robber***

### *Building*

We built the Robber all black and red to make it look like a baddie. At first we built it too big so we took it apart and rebuilt it. Then we put the gears on but they didn't work very well so we had to take them off and copy the way the gears on the Owner were built. The Robber has two motors, one driving each wheel at the back and two sliders at the front. The gearing is the same as on the owner.


The Robber. Front view.

It has two light sensors, one near the ground and the other pointing out to the right hand side. The first light sensor is to get the robber to follow the black line inside the house to get to the jewellery.
The second light sensor is to sense the light near the jewellery cabinet and signal it to stop.
The Robber also has a bumper at the front. This is on a spring and when it runs into a wall the bumper hits a touch sensor. We found an example in a book where the bumper would be on the touch sensor and would release it when it hit something. We couldn't get that to work. We moved the bumper so that it would press the touch sensor instead of release it and this worked.
The RCX is inside the Robber and there is a space at the front for the RCX to send and receive signals.

### *What it does*

The Robber comes into the house. It sends a signal to the door to open. It waits while the door is opening, then it moves inside and sends a signal for the door to close. When the door is closed it moves on into the house. It keeps going until it hits the wall at the other side.
Then the bumper presses the touch sensor. This stops the motors and reverses for a couple of seconds and turns. It then goes on and meets the black line. It follows the black line to the jewellery cabinet.
It opens the cabinet, collects the jewellery in a bucket at the front, and when the Owner comes back and screams it escapes through the back door.

### *Programming*

The programming was very complicated. First we programmed it to move forward by turning on the two motors. It moved forward for about 6 seconds and then stopped and sent the signal (No. 1) for the door to open.

Then it waited for the door to open and then moved on again far enough to get inside the door. Then it stopped and sent the signal (No. 2) for the door to close. It waited while the door closed and then moved on again.

Robber front showing the bumper and light sensor.

When it hit the wall the bumper pressed the touch sensor. The touch sensor was programmed to stop the motors, reverse both for 3 seconds and then to turn on one motor forward and the other in reverse for 2 seconds. This would turn the model to the right.

Then it was programmed to turn on both motors going forward to move the model ahead again. This would bring the model towards the black line. When the first light sensor spotted the black line it was programmed to turn off the right hand motor, turn on the left hand motor for 0.7 seconds.

This would take the model a little to the right hand side of the line. Then the left hand motor would turn off and the right hand motor would turn back on. This would bring the model back to the line. When it reached the line the program would start again and the model would keep following the line zig zagging along.

The second light sensor was pointing to the right. When it spotted the light near the jewellery cabinet it would stop both motors and send a signal ( No. 4) to the jewellery cabinet. This was the signal for the cabinet to open. It then waits 20 seconds which is long enough for the jewellery cabinet program to run. Then it reverses for 2 seconds, to leave enough room for the doors of the jewellery cabinet to close.

The Robber now needed a different program to get out of the house. When the jewellery is unloaded, we send a message from the remote control to change from program 4 to program 5.

Program 5 is waits for a signal to begin. The signal is No. 5 and it gets this from the owner when the owner comes back into the house.

When it gets the signal it reverses for 12 seconds. Then it makes a left turn by turning one motor forward and the other backward for 7 seconds. This should have it almost facing the back door. It now sends a signal to the back door (No. 8) for the door to open. Then it waits for 25 seconds to give the door time to open and then it moves ahead out the door.

If it is not going straight for the door it will hit the wall with the bumper first. This time the bumper is programmed to reverse for 2 seconds, to turn on the left motor for one second and then to turn on both motors and move ahead. This changes the direction slightly to the right. If this is not enough it will do the same again and eventually make its way out the door.

Side view of the Robber. The bucket at the top is intended to be his swag bag!

### *Problems*

The first problem was the gearing. When we copied the gearing from the owner this solved this problem.
The next problem was the bumper. We tried the one in the book but we had to change from releasing the touch sensor to pressing it.
We had a second touch sensor to stop at the jewellery cabinet but we were having problems with several touch sensors and we changed to a light sensor.
We had problems with the model moving on the timber. Sometimes it didn't run straight and it got stuck in the door. If the bumper got pressed at the door the whole program went wrong.
The only way we could solve this was to keep watching it and straighten it up if it was going crooked.
A big problem was when we needed to change to another program to go out. When we used the remote control to change the program from Program 5 to Program 4 it also changed the program of all the other RCXs that were on. They were all running on Program 5 and we changed them all to Program 4 and everything stopped.
We couldn't turn them all off because they were working at the same time.
We came up with an idea. The robber would come in using Program 4. Then we would change it to Program 5. This would not affect the other RCXs because they were already on Program 5. It would send them back to the beginning of Program 5 but this was not a problem because they were just waiting for a signal anyway.
By: Ethan, Jamie, Nicola, Róisín, Sarah, Michael, Zephlin.

## ***The Doors and the Jewellery Cabinet Building***

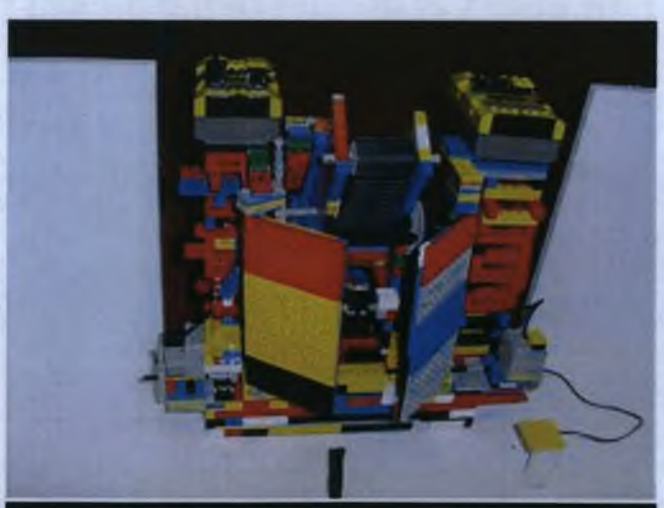
### *Building the Doors*

The two doors were built the same. We used the biggest Lego base we had and fixed on an axle on one side. We ran the axle through the special green bricks with the axle-shaped hole in them. This meant that when the axle turned so would the whole door.
The door had to be wide enough to allow the Owner and Robber to pass through. The door was heavy and to get it to open and close without breaking we had to get it moving slowly. The best way to do this was to slow it down with a worm gear.
The worm gear is connected to a 24-tooth gear and this gives a 24 to 1 gear reduction.

This is the tower we built to support the door. The RCX is at the bottom and the motor is attached to the base beside the RCX.

### *Building the Jewellery Cabinet*

We built two high towers at each side and put a door on each side using bases as doors. The doors could open out and close back in again.
We built a kind of conveyor belt that would drop down when the doors opened. Then it would begin to spin around and this would bring out the jewels and they would fall into the bag of the robber.
We needed four motors altogether, two for the doors, one to raise and lower the conveyor belt and one to make it spin.
You can only run three motors from an RCX so we had to use two RCXs. We had to slow down the gearing on all the motors or else the doors would fall off or the conveyor belt would break.



The Jewellery Cabinet. The two doors are partly closed. You can see the conveyor belt in the centre above the doors. The motors for the doors are at the bottom left and right. The two RCXs are on top.

### *What it does*

The Doors

The front door opens when the Owner or Robber, are coming in or out.
It closes when they have gone in or out.
The back door just opens when the Robber is leaving.

The Jewellery Cabinet

There is a light in front of the cabinet. This is the signal for the Robber to stop so that it is in the right place when the jewels come out of the cabinet.
The two swinging doors open to make room for the conveyor belt to drop down. The jewels are on the conveyor belt and when it begins to turn they are carried out and fall into the bag of the robber. Then the conveyor belt stops, it goes back up again and the doors close in front of it.

### *Programming*

The Doors

The back door is programmed to wait for a signal from the robber (No. 8). Then the motor turns on. It stays opening until the door touches a touch sensor. Then it stops.
The front door is programmed to open when it gets the signal from the owner or the robber (No. 1). The motor turns on and it stays opening until the light sensor on the top of the door spots the light on the wall. Then it stops.
The signal to close is No. 2 and it stays closing until the light sensor spots the light at the top of the other wall.
It also turns on a light on the ground outside the door. This light tells the owner where to stop and turn around to send the signal to close the door.

The Jewellery Cabinet

The two RCXs are waiting for a signal from the robber (No. 4). When the robber stops it sends the signal one RCX turns on the two motors to open the doors. The motors are turned on for about 9 seconds.
The second RCX waits for this length of time and then turns on the motor to lower the conveyor belt. There is a touch sensor under the conveyor belt and when it is touched it stops the motor.
Then the second motor turns on the belt and this brings out the jewellery. The belt spins long enough for all the jewellery to be emptied. Then the motor stops and the first motor turns on again in reverse to raise up the conveyor belt again.
Meanwhile the first RCX has been waiting enough time for all this to happen, about 20 seconds, and then it turns on both motors, in reverse, to close the doors.

### *Problems*

The Doors

The size of the doors made it difficult to get them to open and close. The worm gear helped to solve the problem. When the door opened or closed it stopped when the light sensor spotted the lights.
The problem was that when the door began to open or close the next time it spotted the light straight away and stopped.
To solve this we programmed the RCX to turn off the lights each time the door stopped. Also when the door started up the next time it waited for 6 seconds before it turned on

the lights again. This gave the light sensor enough time to swing away from the lights before they came on.
Sometimes the door stopped when we didn't expect it. We discovered this was if the sun was shining in the window. It affected the light sensor as if it was seeing the lights. We stood in front of it to solve the problem!

The Robber has just stolen the jewels.

<u>The Jewellery Cabinet</u>

We had loads of problems.
It was very hard to build the doors. We had to use a worm gear to turn them and they had to be built in opposite directions. It was very hard to get the housing for the worm gear to stay in its place. It is very hard to join it to other Lego pieces.
The doors were supposed to open and close until they hit touch sensors and the sensors were supposed to stop them. Several of the touch sensors didn't work. Some of them worked some of the time and not other times. We couldn't trust them.
In the end we set the doors opening and closing for so many seconds and then stopping.
Because we had four motors, lights and touch sensors to run we needed two RCXs. This meant that the two RCXs had to work together and we had to time each part of the program so that they did everything in the right order.
One of the RCXs was behind the doors so it couldn't get the signal because the doors were closed until the signal was sent. We had to put both RCXs on top of the towers so that they could get their signals.
We had to make the RCXs beep when they got the signal so that we would know if both of them picked up the signal or just one of them.
If something didn't work it was hard to figure out where the problem was because there were two RCxs and lots of wiring.

By: *Owen, Sinead, Ciarán, Roseanne, Emma, Shane, Marie, Caroline.*

# Appendix J

## *Tomás Comparison between philosophies of Irish Revised Curriculum (1999) and the Empowering Minds Project*

(The text that follows has been taken directly as published on the school web-site)

| **Revised Curriculum** | **Empowering Minds PROJECT** |
|---|---|
| Central Methodologies | Key Features |
| Talk and Discussion Collaborative/Co-operative Learning<br>Active Learning Strategies<br>Problem Solving<br>Use of Local Environment<br>Skills Development through Content | Talk and Discussion Collaborative/Co-operative Learning<br>Active Learning<br>Problem Solving<br>Projects developed from Children's own experience Skills developed as children express need |
| Key Methodologies | Key Methodologies |
| Co-operative Group Work<br>Guided Discovery<br>Play and Co-operative Games<br>Investigating/Exploring<br>Learning through Language<br>Reflection and Action<br>Story Telling<br>Problem-Solving Experiences<br>Active Learning/ Hands-on Approaches<br>Use of ICT, Media, Photographs, Questionnaires, Interviews<br>Whole Class Teaching<br>Active Learning Process<br>Engages Children at different Levels<br>Requires atmosphere of Trust and Support<br>Requires Teacher to Guide and Direct Work | Collaborative Learning<br>Developing Problem-solving Strategies.<br>Children learn to 'think about how they think'.<br>Learning with Technology not about Technology.<br>Cross-curricular Integration.<br>More Relevant and Meaningful Learning.<br>Improved Confidence and Self-esteem.<br>Children create External Structures to facilitate Conceptual development.<br>Children become Designers.<br>Children learn to control their Environment with Technology. |
| Co-operative Learning Roles | Co-operative Learning Roles |
| Questioner<br>Recorder<br>Speaker<br>Encourager<br>Observer<br>Researcher | Questioners<br>Recorders<br>Reporters<br>Encouragers<br>Observers<br>Researchers<br>Builders<br>Designers<br>Organisers<br>Photographers<br>Programmers |

| Group Learning | Group Learning |
|---|---|
| Sense of Purpose<br>Learning from/with Others<br>Language Skills<br>Sense of Democracy<br>Interpersonal Skills | Sense of Purpose<br>Learning from/with Others<br>Language Skills<br>Sense of Democracy<br>Interpersonal Skills |
| **Collaborative Learning** | **Collaborative Learning** |
| Aims to provide opportunities for students to engage with knowledge, concepts and skills in a way that allows them to make connections between their existing experience and the 'new learning' they are engaged in. | Aims to provide children with the opportunity to create external structures with which to facilitate conceptual development and to enable children to develop problem solving strategies and skills at their own pace and in their own way.<br>Aims toprovide children with a means of controlling their environment with technology and improving their confidence in the future use of such systems.<br>Pupils will externalise their thinking and reflect on what they are doing and how they are learning i.e. thinking about how they think. |
| **Teacher's Role** | **Teacher's Role** |
| Supportive Environment<br>Collaborative Ground Rules<br>Subject/Materials<br>Group Size Assignment of Students<br>Classroom Organisation<br>Task and Expected Outcomes Explained<br>Monitor and Intervene<br>Group and Individual Reflection<br>Talk and Discussion<br>Open-ended statements<br>Brainstorming<br>Circle Work<br>Agree/Disagree | Supportive Environment<br>Encouraging Peer Tutoring<br>Collaborative Ground Rules<br>Group Size Assignment of Students<br>Classroom Organisation<br>Task and Expected Outcomes Explained<br>Monitor and Intervene<br>Group and Individual Reflection<br>Talk and Discussion<br>Open-ended statements<br>Brainstorming<br>Learning with Pupils |

# Appendix K

## *Scability: encouraging and promoting the spreading of ideas*

### *Conference presentations by EM project teachers included:*

- Computer Education Society of Ireland, Dublin, January 2001, January 2002, February 2004
- Euro-Prim 2000, Germany
- Learning Hubs Summer Institute, Mexico 2001
- Extreme Interfaces Exhibition – MLE 28$^{th}$ January 2002
- INTO (Irish National Teachers Organisation) National Tutors conference, Galway, May 2002
- National Forum for Disadvantaged Conference – St. Patrick's College Dublin – July 2002

### *Workshops and Talks by EM project teachers included:*

- Kilkenny Education Centre - Postgraduate Diploma in Information Technology
- Digital Hub Learning Initiative team and teacher representatives of all schools within the hub catchment area
- Dublin West Education Centre – Computer Users Group
- Special Class teachers' group from the Finglas / Ballymun area
- Blackrock Education Centre – Teachers Inservice Course and Computer Users Group
- Maynooth University – Postgraduate Diploma in Information Technology Programme
- Dublin City University – MSc programme
- St. Patrick's College – B.Ed elective course, 'Digital Learning'
- Trinity College Dublin – Honours B.Ed students
- The Irish Science Teachers (Post primary teachers) Summer school workshop (10th July 2003)
- Five day summer workshops (August 2003) hosted at Blackrock Education Centre; Dublin West Education Centre; Kildare Education Centre; Kilkenny Education Centre and Sligo Education Centre

***Exhibitions by EM project teachers included:***

- National Young Scientist & Technologist Exhibition, RDS, Dublin, $11^{th}$ –$15^{th}$ January 2000; $9^{th}$ – $13^{th}$ January 2001; $11^{th}$ –$14^{th}$ January 2002; $8^{th}$ – $11^{th}$ January 2003; $7^{th}$ – $10^{th}$ January 2004

- Annual Local Open Day at each school – generally held in the last school term between April – June (2000 – 2004)

- Annual Demonstration day by all schools involved in the project at St. Patrick's College, which is generally held in the last school term between April – June (2000 – 2004)

# Appendix L

## *Significant developments as a result of the EM project*

These developments are evidence of the spreading of the Constructionist principles and the approach to teacher learning advocated by this work

- Independent Teacher Lead Initiatives
- Extension of the NCTE's teacher development programme to include extended immersive workshops informed by Constructionist principles and the computational materials used by the EM community
- The publication of advise sheets distributed to all schools on the computational materials and learning approach used by the EM community http://www.ncte.ie/ICTAdviceSupport/AdviceSheets/ProgrammableBricks/
- The Liberties Learning Initiative within the Digital Hub
- The TeachNet Ireland project teacher professional development programme
- The C2K Mindstorms Learning Initiative in Northern Ireland
- The European Primary Village professional development programme for teachers

### *Independent teacher lead initiatives*

The Empowering Minds group has hosted many visits from teachers interested in using the computational materials. Many of these teachers have purchased the commercially available MindStorms kits and have begun working with them in their classrooms. It is intended to provide support for these teachers and build resources on our website in response to queries we are receiving from these teachers about problems they are experiencing. Arrangements have been put in place so that these teachers can participate in the immersive workshops that have been organised for some of the other initiatives. One example of these developments is Milo Walsh a former teacher and now director of the Co. Wexford Partnership who equipped a small rural school (Rathgarogue N.S.) with MindStorms materials in June 2002.

```
Hi Deirdre,
                Just when you thought you would never hear from me.
Please find attached a few shots from a Rathgarogue N.S. County
Wexford a small rural school that has started the Mindstorms
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programme. It has proved to be an outstanding success-especially
with children with learning difficulties. The teacher who has
taken on the programme (Jack Stacey)is amazed at how the project
has taken off....It has been going now since September ...some
students are now progressing into r&d. The Partnership Co. I am
working with are impressed with the concept and its potential.
Thanks for everything.
Milo Walsh (Co. Wexford Partnership)
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(Email communication Fri 24/01/2003 10:21)

***NCTE's Teacher Development Programme***
***http://www.ncte.ie/ICTTraining/Courses/PilotCourses/***

The National Centre for Technology in Education (NCTE www.ncte.ie ) has decided to expand the EM initiative in some way to all Irish Education centres. Initially it is planned to start with a pilot located in 5 centres (Dublin West, Blackrock, Kildare, Kilkenny, Sligo). The initiative is being organised and directed by twelve teachers from the EM group who volunteered their participation. I am part of this design group but it was clearly explained to the NCTE from the outset that my role was not to lead this group. Nor would I facilitate any of the proposed workshops unless there was an emergency as the teachers from the EM group were quite competent to act as the workshop facilitators. Teacher release time was secured for this group to meet and decide on how this learning experience for other teachers should be structured. The most interesting feature of this design phase was that they all unanimously decided that experience for the new teachers should be as rich and immersive as their own and would use the same set of computational materials initially. The teachers highlighted that being consistent to Constructionist principles was of ultimate importance. They strongly indicated to the NCTE that these workshops would not conform to a predetermined set pattern or the typical teacher inservice that was common to the NCTE's other programmes. Nor would there be a course manual that was the general practice for NCTE's teacher programmes. They argued that due to the underlying Constructionist principles each of the workshops would be very different. It would be the participants' interests, needs and experiences, which would provide the direction and focus not a predetermined content decided by them. Instead they agreed to develop a general set of resources that could be used at workshops if and when they were deemed appropriate (Pictures, video clips of projects in development from a variety of classrooms; children's accounts of their work; descriptions of projects engaged in, problems encountered etc.). These resources would be uploaded to the EM community's learning space on the web (http://empoweringminds.mle.ie) and available to everyone. The structure of the day was also to remain flexible with reflective sessions interspersed with building sessions. They also insisted that adequate computational materials had to be provided for each centre with facilitates put in place for teachers to be able to take the equipment 'on loan' to their own classrooms for an extended period of time. Arising from their own experiences their reasoning to the NCTE was that teacher development did not happen in isolation but was strongly tied to classroom practice. Stand-alone workshops therefore were not what they wanted to be part of. The workshop experience had to have some means of being brought into the everyday life of the classroom. Funding was not available to provide computational materials for all participants' classrooms so the minimum that was acceptable to the group was that an agreed number of 'kits' would be available on a loan basis for teachers to use in their own classrooms. Being able to bring the materials into the classroom allows the teachers to work alongside their students on personally meaningful projects informed by their own particular context. Teachers can then make informed decisions about how to use their budget or grants provided by the NCTE and the DES to purchase their own supply of these computational materials.

The design group were very conscious that providing support for these teachers as they began to use the computational materials was going to be vitally important. Face to face support in the classroom although highlighted, as being of enormous value to them was not going to be possible. There was no funding available to release teachers from the EM group from their own classrooms to visit the new teachers. The NCTE did however agree to provide funding for resource evenings in the Education Centres and the EM group agreed to trying to provide additional support through the use of discussion forums on the web site. Witnessing how the EM teachers designed the proposed new teacher learning initiative was a very fulfilling experience as I saw concrete evidence of the scalability of the ideas and principles that I had set in motion with the EM project.

In August 2003 a weeklong workshop was organised for each centre facilitated by experienced teachers from the EM project. A support network for these participants is currently being put in place. This pilot is being evaluated and its results will determine the direction of the future of this initiative. Providing an appropriate framework for support particularly face to face classroom support to teachers is an issue that will have to be addressed if this initiative is expanded nationwide. When individuals are required to act as support to other teachers, the normal practice is generally to withdraw a teacher on secondment from their classroom. For example, the

NCTE has seconded practising teachers to facilitate, the management of particular programmes e.g. SIP project co-ordinators; ICT advisors based in local education centres. However, a better use of resources could be adopting the concept of "the half time teacher". This would mean two teachers sharing one teaching position in a school and acting as support to teachers in other schools. In this way the 'support teacher' is still involved at the local school level so there is not a haemorrhaging of the innovative teachers from the system. They are also engaged with learning on a multitude of levels – with the children in their classroom and with other teachers and children across a number of classrooms. They would also have 'street credit' with their colleagues as they would still be seen 'one of the troops' working in a classroom on a regular basis rather than just administering a programme.

***Liberties Learning Initiative [http://www.thedigitalhub.com/index.asp?i=212](http://www.thedigitalhub.com/index.asp?i=212)***

I am also involved working with The Digital Hub[1] team to design and co-ordinate a learning strand entitled 'Liberating Learning' for the Liberties Learning Initiative. The Liberties Learning Initiative has received €1.3 million in funding from Diageo Ireland[2] and will initially fund the 'Liberating Learning' (LL) initiative for two years (September 2003 – August 2005). . A fulltime co-coordinator, Clifford Brown has been appointed from the Empowering Minds teachers' group who will liaise with a small co-ordinating team from the Hub and myself to develop this exciting new LL initiative. We will be working with all the schools within the catchments area of the Digital Hub i.e., 11 primary schools, 5 second level schools and two Youthreach groups. In common with the EM project the programmable brick is the core technology to be used. The primary classrooms are using the RCX brick but in the post-primary classrooms we are working with a larger range of sensors and the smaller controlling device called the 'Cricket'[3]. The EM project's immersive Constructionist approach to learning is continuing and the more experienced teachers from the EM community are supporting the new teachers as they begin to working with the computational materials. For example, the first teachers' workshop for the 11 participating primary schools (5th – 7th November 2003) was facilitated by the LL co-ordinator and two experienced teachers from the Empowering Minds group. A further workshop was been organised in collaboration with the University of Bremen (12th – 16th November 2003) for the post-primary teachers in the Hub. Fred Martin and myself will facilitate the workshop. Fred,

[1] http://www.thedigitalhub.com
[2] www.diageo.com
[3] http://www.handyboard.com/cricket/

a professor at Lowell, University of Massachusetts and formerly of the Media Lab at MIT is the developer of the Cricket technology that we will be working with at this workshop. Four experienced teachers from the Empowering Minds group also participated in this Cricket workshop. These primary teachers from the original EM group will also use the crickets with their students and will support the teachers in the Hub.

***TeachNet Ireland***
***http://www.teachnet.ie***

Besides the EM project I have also tried to explore how Constructionist principles could be applied to the design of other computationally rich teacher learning environments. TeachNet Ireland is one such example and is a national initiative that I am responsible for directing. TeachNet Ireland, which began in October 2001, is an initiative of St Patrick's College, in association with the Teachers Network New York[4] and is funded by the Citigroup Foundation[5] and Atlantic Philanthropies[6]. Lack of relevant curriculum content had been identified by Irish teachers as one of the reasons for not using the Internet in their classrooms. In an effort to address this expressed need TeachNet funds teachers to design, develop and publish classroom projects which make use of the Internet and other computational materials in meaningful and interesting ways. The projects aim to go beyond technical skills development, and to help teachers to reconsider their view of teaching and learning. In common with the EM community these teachers are engaged in constructing an external artefact (an online project) and the focus is on classroom practice. Similarly the teacher professional development programme is designed to take account of the teacher's prior experiences and to meet their expressed needs and interests. Just as in the EM community every effort has been made to provide a flexible supportive framework for teacher learning. Support is provided by regular workshops in response to teachers expressed needs. These workshops are funded by the NCTE and facilitated by the more experienced teachers within the TeachNet community and faculty from St. Patrick's College.

> The workshops were excellent. Tutors gave input and individual support. This was significantly different to other courses where tutors have to adhere to specific topic regardless of individual student needs. Having met the personnel I was much more

[4] http://teachersnetwork.org/
[5] http://www.citigroup.com/
[6] http://www.atlanticphilanthropies.org

> comfortable contacting with queries. (TeachNet external evaluator's report, 2003, p.26)

Peer-to-peer feedback sessions have also been organised and teachers are supported in their thinking about learning issues by faculty at the college. Technical support and advice on how to use particular software or computational tools is provided on an individual basis by a team of technically fluent classroom based teachers within the TeachNet community. In common with the teachers in the EM community the teachers within the TeachNet community are using their own classroom experiences as their 'object to think' with. Constructing their web-based project provides the context within they are beginning to confront some of their beliefs and assumptions about learning and examining their role as a teacher. This is evident from some of the teachers' comments in the external evaluator's report:

> The TeachNet experience related in a more relevant way to our role... It took the focus away from the purely technical. (TeachNet external evaluator's report, 2003, p.26)
>
> This project has shown me that the use of Multimedia in education has the power to change the way teachers teach and the way that children learn. It has fostered a more student-centred and less teacher-centred method of education. (TeachNet external evaluator's report, 2003, p.16)
>
> This project had a significant impact on my own teaching and my ideas on teaching and learning. The project has energised me professionally, it has motivated me to use a multi-sensory approach with my students and it has convinced me of the importance of active learning by students. (TeachNet external evaluator's report, 2003, p.16)

However as found in the EM project this change in teachers' beliefs needs adequate time to develop:

> In the first year of the project, there was little indication of any change in the educational beliefs of the participating teachers. This changed in the second year. Many of the teachers explicitly reported changes in their beliefs and attributed the changes to participation in the project (TeachNet External evaluator's report, 2003, p.18).

As the third year of this project commenced a small number of teachers from this TeachNet community have joined with teachers from the EM community to form the first cohort of students who are starting a postgraduate diploma in "Digital Learning" based at St. Patrick's College.

What I have outlined above are developments that have mushroomed from the EM project and the Constructionist approach to teacher learning that has been promoted within this learning initiative.

***C2K initiative in Northern Ireland***
***http://www.c2kni.org.uk/***

Carol Mc Allister from C2K[7] in Northern Ireland visited on 15th May 2003 to discuss and explore how best to initiate a similar project in Northern Ireland. They had secured the licensing agreement for use of the RoboLab software[8] in all Northern Irish schools but wanted advise about how best to use this type of technology in the classroom. Carol and a colleague spoke with me at length and visited two of the EM schools. They took video footage of the teachers and children at work with the computational materials and sought their advice and recommendations. Arising from this visit they have been successful in securing funding to set up a pilot project using the 'programmable brick' technology and the Robolab software. This pilot will involve schools from each of the 5 Education and Library Boards (ELBs), and it is planned to involve the ELB Curriculum Support Officers to provide classroom support for the new project. Collaborative links will be maintained to help and support this pilot with the hope that a more substantial link between the schools in the north and south of Ireland can be developed in the future. We are currently actively seeking funding sources that will help consolidate this linkage.

***European Primary Village***
***http://www.primaryvillage.eu.org/ and http://comcdb.programkontoret.se/CourseManagement/ASP/CourseInfo.asp?CourseId=4880***

This project has a European dimension now and plays an important role in a project co-ordinated by Emile Bourdin, CEO for Education Catholique in the Maine et Loire France (also participating are Vienna School Board, Kultusministerium Mecklenburg-Vorpommern Germany). Hugh Gash and Deirdre Butler are the Irish co-ordinators for this project, entitled, "European Primary Village - A European concept for professional development for primary schools" (PROJET COMENIUS n° 94145-CP-1-2001-1-FR-COMENIUS-C21). European funding under the Comenius initiative (274,395 euros) was granted over three years (2001-2004) for the development of this

[7] www.c2k.co.uk
[8] http://www.ni.com/company/robolab.htm and http://www.ceeo.tufts.edu/graphics/robolab.html and http://www.lego.com/eng/education/mindstorms/home.asp?pagename=robolab

project. The French and Austrian partners in this project visited some of the classrooms in the EM community.

The French teachers from this group were particularly interested in the Constructionist approach to learning and visited Ireland for a professional development module, which took place at DCU and St. Patrick's College over a period of 5 days ($7^{th}$ $-14^{th}$ May 2001). The focus of this development was improving their English speaking skills and to visit and work with the teachers in the Dublin based schools of the Empowering Minds project. This group of teachers returned ($31^{st}$ March – $5^{th}$ April 2003) to visit the small rural schools of the Empowering Minds project and engage in a hands-on experimental workshop using expressive computational materials. Deirdre Butler and a team of teachers from the Empowering Minds project were responsible for the design and facilitation of these workshops. These two experimental professional development pilot courses will form the basis for the COMENIUS teacher professional development course (FR-2004-05) planned to take place in Angers – France from $22^{nd}$ May until the $30^{th}$ May 2004. Teachers from the EM community together with some of the French group will be the facilitators for this European initiative.

# Appendix M

## *Developments observed in preservice teachers who had engaged with the Digital Learning coursework*

Statements taken from interviews during May 2002 with students who engaged with the Digital Learning elective course (Oct. 2001- May 2002) during the final year of their undergraduate degree programme.

**Overcame fear of using computational materials**

*I'm more willing to try things out and am not afraid of technology anymore. H.*

*I'm not afraid of computers anymore. I was an absolute disaster, if there was such a thing as a computer dyslexic that's what I was... I'm definitely more interested in new things...I've even found myself looking at digital camera ads ....I feel I'm becoming more computer fluent N*

**Increased confidence and were more adventurous in trying things out**

*Now more confident to mess around and try things our – AM*

*Until you see it in action you don't know it will work really. Sometimes you have a reluctance to try things out but if you see it in action you've much more confidence in it and in yourself to try it out and that it works...You can see the value of experiential learning, using concrete materials and working in groups. ME*

*I've gained a lot more confidence and I'm willing to experiment. I'll try different things. N*

**Awareness of the importance of experience for building understanding**

*Unlike the other courses we were taught everything but we never actually got experience of doing things... They were talking about the children doing problem solving but we never saw it. But now we're actually seeing it ...we've got the practical experience. B*

*A lot of the time you're just sitting in the lecture with the lecturer going on and on and you're writing it down and you don't understand it. You're saying to yourself "help, what's happening here". You've no real practical experience of it at all. The only time you have practical experience is on TP and that's very formalised and you don't want to go too wild either with the students in case something happens. B*
*All the courses done so far have been child-centred, constructivist in focus. This course reinforced that in a concrete more practical way-facilitating constructivist teaching. BR.*

*The school visits really gave me an insight into what was really going on in classrooms... It is possible to think about situations but you'll never really going to gain the same understanding as when you're actually working with the materials yourself and seeing other people work with them as well. C*

*You go through college and you say "Oh I must do this or try that". It doesn't really make you strop and think really whereas when you go out and see kids doing this new type of learning you say "Yeah it does work". Unlike theory, which is just in a book, the evidence is there when you go out to the classroom. M*

*When you only hear about things you're inclined not to believe it. When you see it in action you say "Yeah it does make sense and it can be done"... it makes it more concrete for you...The constructionist theory of knowledge ...that they're always telling us about can be done through computing. MT*

**Dispelled the myth that the teacher had to know everything**

*You don't have to know everything. You can learn from them and you're not going to fell threatened by this. AM*

*The kids knew far more than we did. When we were in Primary school the teacher would never say she didn't know everything. If she did the kids would probably have dropped dead on the spot and the teacher would have to retire or something... We wer told in first year by Catherine Mulryan that the teacher didn't have to know everything but we never believed it...like we knew we didn't know everything but we weren't going to admit it to the children. So this was a new experience to say I don't know what's going on there ... so can you tell me. B*

*It's given me the confidence that you don't have to know everything. I've seen that the teachers don't know everything about it [computational materials] but that doesn't mean you can't use it. M*

**Comfortable with the concept of working with and learning alongside their students**

*It doesn't matter who came up with the ideas you were another student among the students. You were both focused on getting whatever problem it was solved. AM*
*Teaching Practice was very formalised but with this you could learn a lot from the kids.B*

*I'm learning alongside the kids...it's not like teacher has learned something and now we pass it on to the kids. You keep learning stuff as you go along. M*

*Teachers don't have to know everything. They can solve problems together with the kids and learn side by side. It's a more positive form of education. MT*

*I'm less afraid of knowing less. I wouldn't be afraid now to go into a classroom and the kids knowing more than me. R*

*I realise that it's ok to let the kids know that you don't have all the answers that you can work it out together, that they can teach you. Y*

### More adventurous in trying ideas out on Teaching Practice

(for example, using computational materials, designing active learning environments, group work, discussions, devolving more control to the students)

*Comparing my TP's (teaching practices) no matter what subject I was doing I'd have them more active 'cos I saw that it wasn't as threatening. When you'd be doing it in a lecture they'd be saying it was great and all that but you'd be kinda going "look I got through it this way so I can get everyone else though it that way". But then when you saw it wasn't as threatening as you thought, you'd be more comfortable with it. So you were prepared to go out and try it and you didn't mind doing it...You wouldn't be afraid anymore to go out and give it a bash. AM*

*It's made me more confident...I'm not afraid of the class getting out of control if they're talking or if they're out of their seats and walking around. I know its ok....I tried a group activity in Science on TP. There was water and stuff everywhere and the kids worked in groups. I would have been afraid of doing this before. Y*

### The beginnings of self-determination and a realisation of lifelong learning

*You begin to think more and wonder what else is out there that I can get to know that will help the students and me. AM*

*We were talking about learning and trying to verbalise how we learned. We realised that it's very hard to do that 'cos we never had to do that before. But when you do verbalsie your own learning it becomes clearer to you. Once you reflect on how you learn yourself ...you begin to realise what is going on in the learning process. MT*

*I never reflected on my own learning. This [Digital learning course experiences] did force me to reflect on it. It definitely triggered me to think about my own learning. ME*

*With this course I've been forced to think more about how I think about things...I've been looking around and there's another computer course for teachers that I'd like to take up when I leave here. N*

*I'm more aware of how children think and I'm more aware that I have to be aware of it. NN*

### Changed understanding of the teacher's role and the learning process

*It was their idea that they were working on and there was no set way to go about things so you could go with the flow and you were able to stand back to watch and observe... You learn an awful lot by just standing back – if you just move out and watch AM*

*When I was in primary school the teacher would be at the top of the class. She'd write things on the board and we'd write it down. She'd say something and we'd write it down. This time the children would make their own interpretation and sort the problem out their own way. B*

*The children have to work through the process of it themselves... the teacher is there as an overseer to help and guide them if needed but it's mostly the children themselves, learning themselves, teaching themselves really.B*

*I've learned a lot about how children learn ...that they just don't learn in little compartments. C*

*The teacher was guiding them, prompting their understandings by getting them to question. But it was really coming from them not outside. It wasn't externally imposed it was internally driven. M*

*I've seen an alternative way of learning. Rather than standing in front of the kids and teaching them didactically and spoon feeding them. The kids are actually active and it's not just the students, the teacher is there learning with the kids...Beforehand the idea that the teacher has to have authority and you'd be afraid that if the teacher doesn't have authority then learning wasn't taking place. But in these classrooms where the teacher was working gin partnership with the kids they don't have full authority as the kids have freedom so it shows you that learning can take place without the teacher having full authority....I'd be more inclined now to use technology and allow kids to control their own learning. MT*

**Broadened perspective of what a learning environment could be**

*It gave you a chance to see how the kids worked together and how they were progressing 'cos you didn't have to be there instructing them and telling them what to do next. AM*

*Learning does not have to be out of the text book of the teacher telling the children. The children can talk about it themselves, interpret their plans and different opinions that they have and then apply it to the particular situation. B*

*I've never seen teachers branch out that much before. I thought group work was as experimental as teachers might go. But this makes learning so exciting. N*

**Realisation that children are capable of setting their own learning goals**

*... the children would make their own interpretation and sort the problem out their own way. B*

*...this demonstrated that children were becoming active, independent in tehro won learning. They were not relying on the teacher. That they realised that if there's a problem, "Well we can work this out". Rather than going to the teacher saying "Help what do you think we should do ?" C.*

*The problems are their problems, they're not the teacher's problems or problems that have been set for them. In other subjects you give them problems. They're meant to be their problems but they're not, they're your problems that you want to see that they are able to work through. But using the Mindstorms they are their own problems not teacher's problems – teacher doesn't probably know how to do them but they are well able to do their own , make their own ideas and use their own resources. M*

| |
|---|
| *The kids are in control. The teacher guides and facilitates the learning but he kids are in control of their learning. MT* |
| **Challenged assumptions and beliefs about learning**<br><br>*This gave me a greater insight into what education can be and the possibilities for me and the kids. AM*<br><br>*This time we could go out into the schools and focus on a group of children and watch them and see the way that they learned. It changed the way we thought. B*<br><br>*We were brought up thinking the teacher talks, you listen, then you remember it all and regurgitate it in the exam. The teacher gets praise and you get praise 'cos that's the way things happen. That was how I learned up to Leaving Cert and even in college exams that's all I've ever done so far is regurgitate the knowledge we've been told in lectures. This points out that there's a different way to learn. You can say if you don't understand something, talk it out , work around it, apply it to other situations and see if you can work it out in different ways. B*<br><br>*It made me realise that my own learning is so limited. I've always got through school with rote learning stuff. I don't have the resources that some of these kids have using the materials. They're so resourceful, if one way doesn't work they'll try out a different way...It's made me more open and aware ...now I can say you don't just rote learn everything there are different ways of learning. M*<br><br>*In theory you think everyone learns differently but you still go our and give the same worksheet to everyone. But this made me think about it. NA*<br><br>*Instead of the books the kids are doing it for themselves and learning for themselves...the teachers didn't tell them what to do.R* |
| **Deeper understanding of relationship between theory and classroom practice**<br><br>*Having Hugh Gash's course drew your attention to it [constructivist learning theory] but it's no good unless you experience it. AM*<br><br>*We never were in practical situation that we could really look at how people approach problems or how they went about learning ...it was very theoretical really. It's all grand in theory ...very many of the courses went against the student centred approach to learning ...but this gave us practical experience ... when we were out in the schools working with the Lego, people worked together and solved problems. BR*<br><br>*You hear in college in a lot of the courses ...that it should be all problem solving and using different methods but you don't actually see a lot of it. But with this is really brings everything together. You can see things happening and that it works and that it's worthwhile doing. It actually brought everything together. Throughout the three years everything seemed to be in different little subject areas. It's only actually now that everything seems to be coming together especially philosophy. This elective brought it into context. C .* |

*This brought together the whole constructivist thing we've been doing in psychology and the problem-posing talked about in philosophy. ...Because we had to discuss it you just didn't take it for granted like you do in a lecture. This was more applied to teaching and learning and not to exams. It had a real effect. NN*

**Broader understanding of how computational materials could be used in learning**

*Now I realise that technology isn't all just sitting at a computer screen that you can bring it into real life. ...I'm much more will to give things a try ... look into things and know where to find out about things... we'd be more open to using technology more...unlike other classrooms where it's segregated we know we can use it across all areas. You could have it at the core of your classroom in everything that you do.H.*

*I never knew the range of stuff that was out there and what you could do with it. M You can use technology without having to sit in front of a computer screen the whole time. MT*

*When the gears don't mesh you can talk to them about it. You can really see the process of thinking. NN*

*I'm a lot more comfortable using computers now and realise that there's so much more to using technology. It's not just putting a CD in and letting a child sit in front of the computer. Y*