Chapter XXIV
Effective Use of Learning Objects in Class Environments

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ABSTRACT

This chapter provides a model to analyse the effectiveness and efficiency of Learning Objects being used in primary and secondary schools by considering their place within that educational environment, paying particular attention to the manner in which they, like any resource, can aid or occlude productive interactions between teachers and students. It draws from a study of Australian and New Zealand schools that piloted the first release of Learning Objects from the Le@rning Federation. The chapter considers the place of Learning Objects within the overall systemic school environment, and in this environment, examines the individual classroom as the combination of tensions between the teacher's needs, the students' needs, and the potential available within the existing infrastructure. Within this framework, the chapter discusses the ways in which these three components interact during teacher selection of Learning Objects, students' accession of Learning Objects in the classroom, and the use of the Learning Objects by students. It concludes by suggesting how students' construction of knowledge can be enhanced through merging the capabilities of the resource with the needs of students and teachers.

INTRODUCTION

The Le@rning Federation began in 2001 as a collaboration between the state, territory, and federal governments of Australia and New Zealand. At the time of writing, it has placed 5,000 digital learning resources online, including a wide range of Learning Objects relevant to Literacy, Numeracy, Science, Studies of Australia, Languages other than English, and Innovation, Enterprise, and Creativity. The scale of government commitment meant that the first round of Learning Objects made available to teachers on the Internet during 2003 were a critical testing ground for this technology. At the same time, extensive guidelines were put in place to ensure that all offerings would be accessible, usable, and have educational integrity with a learner focus, as outlined in the specifications for developers (The Learning Federation, 2002, 2006). Underlying this project was a definition of a Learning Object as

- One or more files or "chunks" of material, which might consist of graphics, text, audio, animation, calculator or interactive notebook, designed to be used as a standalone learning experience
- Reusable—a single learning object may be used in multiple contexts for multiple purposes such as across curriculum areas, year levels, different locales, and cultures
- Usable as a component of a topic or unit of work alongside other digital and nondigital resources and tools
- Accessible from the World Wide Web and is referenced, located, and accessed by its metadata descriptors
- A product that can be identified, stored, and tracked using a content or learning management system (Lake, Phillips, Lowe, Cummings, Schibeci, & Miller, 2004, p. 1).

BACKGROUND

Duval, Hodgins, Rahak, and Robson (2004) noted that "few papers [about Learning Objects] included clear guidelines or methodologies, or analysed in any detail what had worked and how or why it worked" (p. 338). This chapter will consolidate the results of an Australasian study into the impact, application and effectiveness of Learning Objects developed for primary and secondary classroom teaching and learning (Lake et al., 2004; Schibeci, Lake, Phillips, Lowe, Cummings, & Miller, 2006).

The study arose from the early stages of a major government initiative to develop online digital content, and involved case studies of 20 classrooms in 14 schools in Australia and New Zealand.

The four main data collection activities were student observation, student interviews, student surveys, and teacher interviews and observation.

Researchers visited schools in pairs. They spent between 1 and 5 hours in each classroom. Students were observed using the learning object and then about half (based on parental permission) were interviewed. Teachers were also interviewed during or after the lesson. Surveys were administered to students and teachers. In several cases the teacher selected students according to characteristics they felt made them of special interest (for example, cultural background, non-English-speaking background, ADHD, reading or mathematics difficulties). The researchers made no representations in this area. Researchers observed students using a learning object in the context of a normal lesson and did not provide assistance unless students had significant difficulties getting the learning object to operate and directly requested assistance from the researcher. All classroom activity was tape-recorded and transcribed for later analysis.

Semistructured interviews used questions that were developed from the generic evaluation questions and reduced in number refined through use in the classroom during a prepilot study. A second set of student interview questions involving role playing was developed for early-years students. Students were interviewed at their computer or in an adjacent area. Where two students shared a computer, they were interviewed together. Interviews took between 5 and 20 minutes. All interviews were recorded and transcribed for later analysis.

A stand-alone student survey was designed as a two-page questionnaire based on Likert-type statements relating to the generic evaluation questions. It was trialed and refined during the pre-pilot study. The survey consisted of two parts: a common section about general learning object usability, and one with questions specific to the learning area (Science, Literacy, or Numeracy). Responses were obtained from 134 students in six participating classrooms

Semistructured class teacher interviews of 30 to 60 minutes based on generic evaluation questions developed through the Program Logic approach probed issues specific to the way in which learning objects augmented accepted pedagogical approaches within the relevant learning area. However, teachers were encouraged to provide any feedback they felt was important. All interviews were recorded and transcribed for later analysis.

A teacher questionnaire was distributed to one teacher in each of the 10 post-pilot schools selected by The Le@rning Federation for this study, and was used as an exploratory tool, and as a stimulus for discussion.

Qualitative data comprised of 84 documents, consisting of over 55,000 lines interview transcripts from student and teacher interviews, and field notes were analysed using the NUD*IST computer program. A node tree of expected response themes was developed from the generic questions and expanded by issues that emerged from the data. A set of additional "free" nodes was created from unrelated themes and field notes. Data was coded by two research assistants. Initially each assistant worked in collaboration with a member of the research team to increase reliability. Coding was also reviewed independently by other members of the research team.

Responses from student surveys were analysed using the RUMM computer implementation (Andrich, Sheridan, & Luo, 2002) of the Rasch Extended Logistical Model (Andrich, 1988). The RUMM software package uses the Rasch latent trait measurement model, and is suited for cumulative scales. Researchers employed this form of analysis to ascertain the relationship between different features of the learning experience and determine the relative importance of each factor in creating a useful learning experience.

MODELLING THE EDUCATIONAL ENVIRONMENT

It is critical when a new program is implemented, that stakeholders share an understanding of how the program is intended to operate and what it is trying to achieve. Most programs, including this one, produce formal documents describing the program. However, many stakeholders and evaluators also benefit from a process that develops clear and agreed understandings of the program, or program logic. One of the most useful program logic analyses is provided by Funnell (1997, p. 5):

In simple terms, a program logic is a program's theory of action. It is a theory about the causal links among the various components of a program: its resources and activities, its outputs, its short-term impacts and long-term outcomes. Like any other theory, it is testable and should be tested. Making a program's theory of action explicit is

the first step towards testing its validity. Program analysis is the process of identifying and making explicit the logic of a program.

An iterative program logic analysis was conducted with the Field Review Reference Group to explore understandings and assumptions about the nature of the Learning Object model and the pilot Field Review. This included:

- Clarifying the evaluation aims
- Providing the evaluation team with background information
- Identifying documents and data sources
- Identifying underlying assumptions
- Identifying who should be involved in the evaluation
- Assisting the evaluation team in selecting the best opportunities for data collection within the time and budget constraints.

This program logic analysis identified factors required for the success of the initiative and led to the development of four broad research questions which reflect the concerns of Duval et al. (2004) that there should be more "recognition that the important aspects of learning objects are how they are implemented and used, not how they are defined" (p. 339).

1. How useful are the Learning Objects for teachers?
2. How useful are the Learning Objects for students?
3. How does Learning Object design interact with: geography, structures within the school and classroom, socio-economic status, and student diversity to affect the ways in which teachers and students use Learning Objects?
4. What factors, including school and system level issues, impact on the wider adoption of Learning Objects?

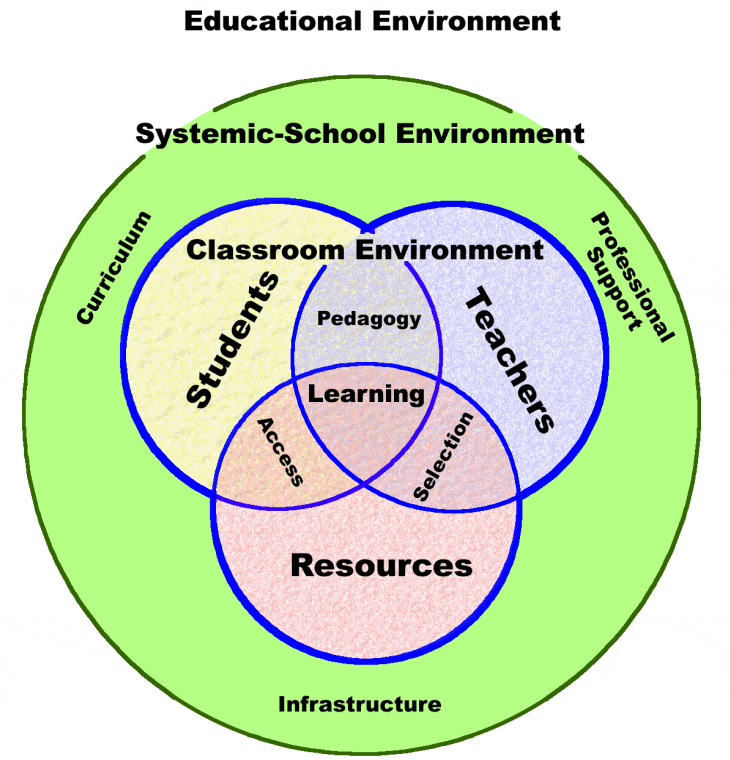
These questions formed the primary focus of the study (see Lake et al., 2004 for a more detailed description of the program logic analysis). Schaffer and Douglas (2004) observed that model components join to create environments and systems and used this to develop a model for metadata storage. Similarly Bouzeghoub, Defude, Duitama, and LeCocq (2006) arranged metadata using the domain, the learner and the object as interacting classes. Fresen (2007) formulated a taxonomy of factors which affect the quality of a Learning Object that include the teacher, the student, the pedagogy, the instructional design, and factors relating to technology and the institution.

The educational environment model described here (Figure 1) was derived initially from the program logic analysis and then further refined from evidence collected in this study. In the program logic hierarchy, school- and system-level support was an overarching factor influencing success, and well-designed Learning Objects were a prerequisite. Two subsequent factors in the program logic were the selection and subsequent use of Learning Objects by teachers. In Figure 1, this is illustrated in the intersection of Teachers and Resources labelled *Selection*. Similarly, the next two factors in the program logic hierarchy concern enjoying and learning from Learning Objects—the intersection of Students and Resources labelled *Access*. The final binary intersection in the model—*Pedagogy*, the interaction of teachers with students—did not arise from the programme logic, but was an important factor arising from the data.

This chapter argues that these points of intersection are the most important areas for promoting learning, and for learning to be maximized, these three components of the classroom environment need to be brought as close together as possible, thus expanding the intersections.

The larger circle in Figure 1 represents the environment of the school and its respective educational system. Together, the classroom environment and the school/system environ-

Figure 1. Model of the educational environment indicating the ways that students, teachers and resources interact with each other and within the larger school/ system environment



ment make up the educational environment. The school/system environment impacts on the classroom in three ways: through the *curriculum*; through *professional support* and development of teachers; and through provision of appropriate *infrastructure*. In the context of this research, the infrastructure is primarily ICT-based, enabling students and teachers to access the Learning Objects appropriately.

TENSIONS WITHIN THE SYSTEMIC-SCHOOL ENVIRONMENT

The classroom environment is shown in the centre of Figure 1, with three main components: Students, Teachers and Resources. Learning Objects are one of the resources that teachers may choose to embed within their teaching programmes. This model posits that the classroom environment exists within a broader school and system-level environment, and there are three primary mechanisms through which the classroom environment interacts with the broader educational environment:

- The relevance of the *curriculum* to students and its coherence;
- The provision of appropriate *infrastructure*; and
- The *professional support* and development of teachers.

Resources and Infrastructure

Using the dominant constructivist pedagogical approach, resources are the tools that teachers use to develop activities where students are able to construct their experiences into a pattern of belief. Learning Objects are one type of resource for providing experiences to help scaffold knowledge. Wiley, Waters, Dawson, Lambert, Barclay, and Wade (2004) cautioned against Learning Objects that fail to scaffold knowledge, but simply seek to deposit knowledge into the mind of the user while an analysis of the ARIADNE project (Põldoja, Leinonen, Väljataga, Ellonen, & Priha, 2006) estimated only 1.4% of objects were based on constructivist principles. At the same time, Baruque and Melo (2004) demonstrated how Learning Objects can be enhance behaviourist, cognitivist, and various constructivist pedagogical approaches.

The ability of the teacher and student to access the Learning Objects depends both on the technical infrastructure and the skills of the individual teacher or student. This study found a wide variety of computing facilities, technical support, and policies for using technology within schools. There was also a wide range of teacher competence and confidence with using the available technology and the Learning Objects. Without appropriate facilities and both technical and operational support, uptake of the Learning Object model is uncertain and is likely to be limited.

The Learning Objects surveyed were not supported by all operating systems. The researchers understand the pragmatism of that decision, and would expect that for Learning Objects to continue to be useful, periodic updates will continue to be required as operating systems change and develop.

McRae (2001, p. 16) reported that "effective whole school planning is critical to the successful implementation of ICTs." For Learning Objects to be effective in schools, all parts of the school community need to be aware of, and support, the initiative. In particular, effective IT support. Widespread use of Learning Objects will require re-examination of IT policies and procedures in some schools, where download limits are imposed to reduce costs, and Internet access can be revoked as a component of behaviour management policies. It will also require Internet use to be viewed as a core activity, rather than a recreational or reward activity.

Learning Objects provide a means to bridge geographical barriers facing students. The equitable provision of quality resources for students in rural and remote regions continues to be a challenge for educational authorities (Lake, Faragher, Lenoy, Sellwood, Archer, & Anderson, 2006) and Learning Objects will undoubtedly continue to be an important part of the solution. The rapid rise in access to broadband Internet services in schools will mean that in the near future Learning Objects will be available to students in the remotest parts of Australia. However, access is not yet uniform and some schools found bandwidth to be an issue, particularly when teachers attempted to have all students in a class access a Learning Object from a remote site rather than downloading it to a local server in advance. Despite these limitations, the Learning Objects already enable many remote students to undertake activities in the same way as their metropolitan counterparts decreasing the educational divide (Lyons, Cooksey, Panizzon, Parnell, & Pegg, 2006), assuming that their teachers are able to make the best use of them.

Teachers and Professional Support

Teachers promote learning, but how they achieve this depends on the particular mix of the beliefs, knowledge, and skills that they bring to the task. Teachers in this study felt more professional support including the identification of time management issues and strategies to address them, was needed to maximize their use of Learning Objects for effective student learning. Professional development of teachers in selecting, structuring,

implementing, and monitoring the use of Learning Objects must be a priority if their full potential is to be achieved in the classroom.

Teachers in this study sought a range of support:

- Guidance in identifying Learning Objects containing appropriate and accurate content relevant to their syllabus materials;
- Advice on techniques for presenting the Learning Object, in particular, suitable introductions and conclusions to the session;
- Advice on class management techniques suitable for lessons incorporating Learning Objects;
- advice on how and where specific Learning Objects fitted into the local syllabus; and
- Advice on how to integrate strategies used in the Learning Objects into their own teaching practice.

Teachers almost universally felt that professional development should be brief, focussed, and integrated into ongoing professional support rather than once-off professional development sessions. One means to achieve ongoing professional support is online communities of practice (see Cummings & Aquilina, 2004; Phillips, 2002, chaps. 1, 2) which can enable:

- Conversations among peers about techniques to adapt generic Learning Objects for specific themes;
- Debates with peers and the wider academic community about the role of the curriculum, and the part that ICT can play in its development;
- Conversations with peers about how to identify and use Learning Objects that will meet special needs of specific students;
- Sharing worksheets and other materials that can be used by students while they are interacting with the Learning Objects; and
- Discussion about how to assess learning achieved through using Learning Objects.

This conclusion is in agreement with Muirhead and Haughey (2003, p. iii) who recommended

The Le@rning Federation should take immediate steps to expand its current mandate to develop communities of practice among learners and instructors involved with the content development initiative.

A second alternative is for the Learning Objects to contain associated information providing teachers with explicit guidance about the ways in which a particular Learning Object may be best utilized, either through release notes or by being embedded within the Learning Object.

Coupled with either option is the need for others within schools to be familiar with the requirements for successful use of Learning Objects. This includes professional development for both technical support personnel and administrators, as part of a whole-school approach.

Students and Curriculum

The classroom, real or virtual, does not exist without students who may be there to learn, but who are also individuals that bring their own experience, needs, motivations, and aspirations. What a student is required to learn is dependent on the mix of sociological, administrative, cultural, economic, and historical factors that shaped his or her curriculum. The particular suite of Learning Objects that were the basis of this study were required to be relevant to the curricula of New Zealand and eight Australian states and territories.

Based on thorough research (McRae, 2001), the Le@rning Federation specified that Learning Objects should be designed specifically from a constructivist perspective where:

The objects should contribute to the learning of the user. They are not meant to be assessment experiences or revision experiences or drill and practice experiences. They are meant to contribute to the understanding of concepts and processes and the development of skills. This does not mean that assessment, revision or drill and practice cannot be exhibited through interaction with the learning objects but this is not the primary focus.(Atkins, 2003, p. 1)

THE CLASSROOM ENVIRONMENT

The model developed in this study views classrooms composed of three factors that interact with each other, as discussed subsequently, but are also in tension with the broader systemic school environment (Figure 1). Individual resources like the Learning Objects must operate within the infrastructure of the school. Teachers are dependent on the professional support that they receive from within the system, and students work within a curriculum setting that is imposed in large part from outside the classroom. The Learning Objects were analysed from each of these perspectives.

The Resource Perspective

The use of the Learning Object as a resource within the classroom environment was dependent on three aspects of the available infrastructure: the available hardware, the available enabling software (such as *Flash* readers), and the policies that determined how they could be used within the classroom.

It is often difficult for those enmeshed in the world of computer technology, usually in large well connected establishments to appreciate that the end-user of Learning Objects, particularly in the primary school setting, frequently qualified before the impact of the technology was felt. She (normally) has a small number of professional development days each year that are devoted, in the main, to keeping abreast of administrative and curriculum changes. Furthermore, her students are likely to have faster, more capable machines at home than those in the school. For example, machines in several schools lacked soundcards reducing the pedagogical utility of many Learning Objects. Finally, most primary schools and many of the secondary schools visited, had no dedicated technician, relying instead on the goodwill of an enthusiastic but not IT-trained teacher to keep the system operating.

The same teachers find it difficult to keep abreast of software trends. While most were accustomed to *Word* and *Powerpoint*, and were able to download digital images from the Internet, many teachers were intimidated by the need to download unfamiliar software packages, like *Flash* readers, where they were not directly obtainable from the official educational authority Web site. Similarly, a familiarity with the point and click simplicity of the Internet made them unprepared for system specific requirements beyond those commonly used for Internet searches, such as requirements to obtain and use passwords or navigate tables of metadata to locate learning objects of an appropriate level for their students' needs. Automatic timed log outs within the delivery systems also prevented some early childhood teachers from setting up the classroom in advance for young students unable to complete these tasks themselves.

School policy was also found to conflict with the successful use of Learning Objects. These policies created the impression that authorities considered computers as an optional motivational tool rather than an integral part of the teaching program. Policies preventing students accessing inappropriate Internet material or reducing Internet download costs led to some schools disabling sound cards or prohibiting earphones. One school blocked downloads of video, audio, and *Flash* files. Another introduced a "bank balance" of download time meaning that some students had used their allowance prior to the class.

The Teacher Perspective

Teachers are the second interacting component of the classroom environment in the model. Despite the obvious importance of the teacher controlling the learning process within the classroom environment, this human factor can be overlooked in Learning Object design (MacLaren, 2004). Overall, teachers in this study expressed enthusiasm about the potential of Learning Objects to introduce a wider variety of learning activities into the classroom particularly activities that were otherwise dangerous or beyond the scope of existing school infrastructure or budgets such as science experiments needing chemicals or materials perceived as hazardous. Teachers also felt that simulations could increase the viability of conducting science experiments that would normally require days or weeks to complete.

However, teachers do not form a homogeneous group. A range of factors affect each teacher's comfort and confidence in using Learning Objects, including their available time to plan, and their familiarity with the curriculum, their students, and the systems and facilities in their school. The teacher's expertise, both in ICT and in discipline areas, is also important in relation to how it interacts with the teacher's pedagogical approach. Technological attitudes, skills, and knowledge are necessary for teachers to organise and guide students using Learning Objects (Ilomäki, Lakkala, & Paavola, 2006)

A wide range in disciplinary literacy was evident amongst the teachers included in this study. This is particularly prominent at the primary level where teachers are generalists, but the majority of Learning Objects were science objects more suited to specialist science classes. Teachers often lack disciplinary confidence and may be only one step ahead of their students (McComas, 2000). Even in high schools there can be no assurance that teachers are specialists within their teaching area (Harris, Jensz, & Baldwin, 2005) especially within rural and remote schools. Within this systemic environment some teachers were using Learning Objects as props to support their lack of depth in the discipline being taught. At the other extreme, others were modifying Learning Objects to provide students with learning experiences that meshed with highly developed, meticulously constructed content programmes.

Teachers' beliefs about teaching, and their consequent pedagogical approaches, affect how they structure lessons and evaluate student learning thus influencing the way they use Learning Objects (Bain & McNaught, 2006). Consequently, there is no ideal Learning Object which will suit all teachers, and resource providers need to provide variety.

Learning Objects could be considered to have the following three possible roles for the teacher:

- Support the teacher to teach in the manner that they are used to;
- Motivate the teacher to provide more enriching experiences for their students; and
- Enable the teacher to discover more enriching teaching methodologies.

These issues, which are broadly congruent with McRae (2001 pp. 92-94), indicate that Learning Object designs must be attractive enough for teachers to choose them (as described in a subsequent section), but should also act as motivators for professional development.

While a number of teachers observed in this study had relatively high interest in ICT and relatively strong computing literacy, it can be expected that the majority of teachers have limited confidence and expertise (Department of Education, Science, and Training, 2001).

The Student Perspective

The case study approach used in this study enabled the investigation of how students of different abilities and backgrounds used Learning Objects.

Almost all students were observed to gain benefit from their use of the Learning Objects, regardless of background. The amount of benefit derived from them depended less on the students' backgrounds and more on other factors including how the design of the Learning Objects permitted them to engage, how the Learning Objects were embedded in lessons, and the teacher expectations and how they matched the general needs of the group and the specific needs of individual users.

Teachers strongly valued the ability of Learning Objects to provide students with new and stimulating ways to learn. Students demonstrated an enthusiasm when using Learning Objects that was not always apparent in their approach to other classroom activities. Bright colours and simple graphics within the user interface engaged particularly the younger students. Humour, particularly through quirky animated characters, was especially appreciated. As also reported by Kay and Knaak (2007), sound and animation incorporated into the multimedia attributes of the Learning Objects, particularly when linked to interactivity, strongly correlated with this engagement. Students found navigation simple where they used the familiar conventions of the Internet and, with some exceptions, they completed tasks using the media well to assist their learning.

McRae argues that Learning Objects need to de-emphasize written text and emphasize the visual.

> *Digital learning can make visual representations of knowledge (through static or moving images and animation) readily accessible. It can "show," model and explicate in ways that verbal ... communication alone cannot.* (McRae, 2001, p. 56)

School students are growing up in a culture where multimedia stimulation is commonplace, unlike the situation when their teachers were young. Therein lies a gulf in education that Learning Objects can bridge. The challenge for Learning Objects is to recognise and exploit this paradigm shift whose pace and parameters are set in other fields particularly entertainment through videogames and the Internet. Students, as experts in the new paradigm, are discerning and demanding when it comes to good communication.

Students did not like reading large sections of text and were less inclined to make appropriate use of Learning Objects containing text-heavy instruction pages. Students generally skipped instructions and experimented instead for one or more of the following reasons:

- A preference to experiment rather than work sequentially;
- A lack of patience when reading lengthy instructions;
- A lack of literacy skills to read confusing instructions;
- A preference for using their time "doing" rather than reading; and
- A perception that the font sizes were too small.

Sound and graphics can provide an alternative to text-based information which afford students with reading difficulties another way of learning. Students enjoy graphics and wherever it does not compromise the learning purpose, graphics should be used in place of text. The graphics need not be realistic, they can be more accessible when they are not (for example when depicting physiological functions). However, students experienced difficulties and frustration when graphics were not clear or factually reliable. Icons were preferred over text for labelling buttons, and colour was important, especially for younger students. The entire suite of offerings for younger students was well received for that reason. Older students focused more on content rather than graphic presentation.

While the need for creative and engaging use of graphics and multimedia and a de-emphasis of textual components was common throughout the student sample, Learning Objects were found to

possess features that are of specific importance to specific groups. Not surprisingly these features were often predictable from the broader educational research literature. For example, Learning Object design needs to accommodate our understanding of educational psychology, recognising the different needs of different aged students. So, young students require and prefer simple cartoon-like graphics with fewer distractions, while older students demand greater complexity and more control over different aspects of the interface. Other important elements of Learning Object design identified by teachers are listed below.

Multimodal Content**:** Learning Objects also enabled teachers to accommodate the differing learning styles of individual students. Visual learners were provided with new and stimulating ways to learn whereas aural elements assisted other students. Some Learning Objects enabled students to experience abstract mathematical concepts in a concrete fashion by allowing them to visually manipulate and observe variables. Effectively, this mimicked the processes considered critical in situated learning (Ovens & Smith, 2006).

Opportunities for Collaboration: for lower-achieving students anonymous feedback is a potential advantage. The vast majority of these students, however, expressed a preference for working in pairs on a computer to gain peer feedback and support, and when working in pairs, teachers observed that they persisted longer than in other activities, reflecting the findings of Põldoja et al. (2006) and Baker, Gersten, and Lee (2002) from their review of the literature surrounding at-risk students in mathematics. Wiley et al. (2004) argue that collaboration is necessary to negotiate meaning, and providing opportunity for collaboration is therefore a requirement of high quality Learning Objects.

Flexibility for Gender: some gender differences were observed. For example a Learning Object about braking distance of vehicles allowed students to investigate using a risk avoidance approach (initially applying the brakes almost immediately and then progressively extending the distance), or a risk acceptance approach (initially applying the brakes almost at the point of impact and then progressively decreasing the distance). Unsurprisingly, given the pan-global stereotype (see, for example, *Mueller, 2004),* the majority of female students were engaged by the former and the majority of males by the latter. Nonetheless, the effectiveness of this means of engagement needs to be balanced by considerations of the ethics of appealing to stereotypes like this in educational material.

Literacy Assistance: teachers reported that students from non-English speaking backgrounds were able to use the Learning Objects as easily as other students, making use of nontextual elements. Students were able to navigate around Learning Objects using visual clues and intuitive logic. Teachers valued sound files to mirror screen text that could be toggled on for students with weak literacy skills. Unfortunately, many Learning Objects assumed that literacy reflected age and so Learning Objects designed for older students often lacked this useful facility.

Cultural Appropriateness: the Learning Objects also provided specific cultural advantages. Shame has long been recognised as a major issue in Indigenous and Pacific cultures. Students from *Pacifica* backgrounds were found to engage positively with Learning Objects that allowed them to test and modify their answers in response to immediate computer-generated feedback, ensuring that the answer displayed to the teacher would not be subject to the shame of rejection by the teacher.

Not only did Learning Objects provide a nonjudgemental environment, they enabled alternative ways to succeed. Students could tackle activities involving experiment and strategy with fewer barriers from text and facts. They were also able to produce high quality work in cases where writing or drawing on paper proved time-consuming and difficult.

INTERACTIONS IN THE ENVIRONMENT

Maximization of the Learning Objects' potential lies in increasing the overlap of the three components of the classroom environment in the model (teachers, students and resources, i.e., Learning Objects) because it is when these are all trying to do the same thing that learning is most likely to occur. The Le@rning Federation (2002) specifications stress the importance of maximising these interactions by promoting accepted pedagogies including constructivism, individual progression, multiple intelligences, collaborative learning and scaffolding of knowledge. Learning Objects offer unique possibilities for teachers to utilise these pedagogies in ways appropriate to their situation.

Selection: Teachers and Resources

The selection process is often where teachers interact with the Learning Objects for the first time during the preparation of their teaching program. Reasons for teachers' selection of learning resources within their programmes are complex. In this study, teachers who had been able to find the resources quickly and reliably selected them according to the ease with which they could embed them within their program, and the match that they saw between the demands of the Learning Objects and the nature of their students. Pegler (2005) described levels of engagement during the selection process where users rejected, browsed, selectively engaged, actively engaged, or augmented the material on offer.

Like the teachers in Li, Nesbit, and Richards' (2006) study, teachers in our study were concerned with making the content of the Learning Objects meaningful to students by integrating them into their teaching and learning programs rather than planning their programs around the Learning Objects. In keeping with this, teachers indicated they wanted large banks of Learning Objects to choose from for specific parts of the curriculum. Like the teachers in McCormick and Li's (2006) study, they expected it to be as easy as using Google and other common search engines to sort through, preview and download with additional content that could extend and support their discipline knowledge to bolster their confidence in the classroom. They also wanted the design and interface of the Learning Objects to be sufficiently flexible to accommodate the specific contexts being used within the programme, in much the same manner as "skins" allow users to customize the appearance of mobile phones without changing the basic control mechanisms or functions. This was partially to embed them within their programme, but also to increase their reusability where other teachers may have used the same resources. The tendency for teachers to select and structure their use of resources to increase relevance for their students reflects the requirements of the outcome-based curriculum with which they work where:

outcomes developed at the state or large-system level ought to be written to enable the specifics of curriculum and pedagogy to reflect a diversity of people and practices, and students to demonstrate their achievement of the outcomes in a variety of ways. (Willis & Kissane, 1995, p.15)

Teachers also wanted contextual information about how Learning Objects could be used and how other teachers had used them. While mechanisms for peer review of ICT-based learning resources have been proposed in the tertiary sector (McNaught, Phillips, Rossiter, & Winn 2000; Taylor & Richardson, 2001), such mechanisms have not matured, nor have they been applied to the schools sector.

Teachers were keenly aware of the needs and capabilities of their specific classes when selecting Learning Objects. However, the metadata recommending age bands for each Learning Object was disputed by many teachers. In rejecting

the metadata, some teachers selected Learning Objects on the sophistication of their graphic interface rather than their cognitive demands creating the potential for a mismatch between student and resource.

Because of their multimedia components, it is sometimes difficult for teachers to assess how Learning Objects make demands on students' literacy, memory and cognitive abilities. A mismatch in any area will result in a less successful learning experience, so selection, task-setting, and monitoring the use of Learning Objects needs to be done thoughtfully. Peer support and professional development have a role to play in enhancing the way in which teachers employ Learning Objects (Baker et al., 2002).

Teachers also appreciated the potential for Learning Objects to demonstrate sensory experiences outside the range of resources and activities that are normally available for their students, such as functions of the human body or plant systems. Many of the Learning Objects fulfilled this potential, but others which provided material and activities within the repertoire of most classrooms and teachers were still used even though students and teachers indicated a preference for real experience. This may reflect the limitations being placed on teachers preparation time, their budgets for materials, and the ethical and safety requirements of the systemic-school environment where switching on the computer is a simpler option. Interestingly, although Nurmi and Jaakkola (2006) observed no significant improvement in mathematics or language learning using Learning Objects, in science there was evidence that the use of Learning Objects while students explored and explained new scientific concepts, coupled with opportunities to corroborate and elaborate on this new understanding by use of real materials did promote significantly superior learning. They suggested that, in science at least, the Learning Objects could promote the development of sound mental models without the constraints imposed by motor coordination when using real materials.

Other strengths of Learning Objects identified by teachers were their potential to:

- Cater for a range of cognitive abilities;
- Match students' cognitive capabilities;
- Assist in providing links between concepts and contexts;
- Provide scaffolding and reinforcement.
- Allow for individual progression and record that progress electronically; and
- Provide new opportunities for collaborative learning.

Access: Students and Resources

The second interaction between the three components of the classroom environment highlighted in Figure 1 occurs during the access process where students first interact with the Learning Object. Li, Nesbit, and Richards (2006) collected user evaluations of Learning Objects they accessed from the eduSource Canada repository using nine criteria: content quality, alignment to learning goals, feedback, motivation, presentation, usability, accessibility, and reusability.

Our study revealed many of the same features. Students in general appreciated their novelty and found many of them interesting, engaging and motivating. Teachers reported instances of increased levels of concentration, enthusiasm and successful learning when students used the Learning Objects. There was evidence that students from a range of abilities achieved success using Learning Objects. The objects engaged students resistant to traditional classroom approaches or those with low levels of academic performance. Disruptive students were observed participating actively in lessons and withdrawn students were observed in purposeful investigations.

The motivation of students was primarily dependent on the way in which the student perceived that the objects recognised their needs and style. Students were motivated using Learning Objects when they were:

- Challenged;
- Able to explore;
- Given control; and
- Provided with useful feedback.

Students desired discrete activities with clear goals against which they could gauge their success. They were not content with "talking books" that proceeded in a linear fashion to a predetermined endpoint without providing them with decision-making opportunities.

Students expressed a strong preference for Learning Objects that were quick to launch and gave them rapid access to clear screen actions which they could initiate through intuitive commands. They preferred Learning Objects that created their own personalities from the skilful and creative use of multimedia. In particular, humour provided by animation or through sound effects was well received. Visual detail, such as that provided in video-clips rather than simple animation, was not seen as a positive when conflicting elements made it difficult to interpret or when the intricacies of the events displayed distracted from the primary focus.

The user interface is the entry point and provides the tools for navigation and interaction. While some Learning Objects had very simple interfaces, others were relatively complex and provided a number of pathways. However, complexity need not detract from effectiveness when the challenge within the Learning Object encourages students to stretch themselves and learn from feedback. Learning Objects providing a number of levels of information that students could access when needed worked well. Most students used Learning Objects intuitively, in an exploratory fashion, in the same way that they use computer games. Unfortunately, the design of some Learning Objects did not easily accommodate this approach, imposing more rigid pathways and relying on detailed instructions at the beginning.

As in Gunn, Woodgate, and O'Grady's (2005) study, it was important that students' interactions resulted in immediate, meaningful and context-relevant on-screen responses. Year 10 students were not satisfied with simple text responses affirming their choices of chemical reagents whereas Year 1 students missed the point of the Learning Object when the inappropriate selection of clothes for a yacht-racing lizard did not cause him subsequent physical harm. But all students from Year 3 to Year 11 were highly engaged and on task when their choices of diet and physiological processes brought relevant consequences for the cartoon character whose purpose was to demonstrate the processes of digestion.

Students appreciated being able to regulate the pace of their learning. They were able to take time to investigate concepts they found difficult in class or to repeat activities as they chose. The ability to engage with a self-contained, self-paced task was valuable for certain students who did not accommodate easily to the fixed-period lessons common in most schools. Students also enjoyed selecting their own multiplication problems or setting the variables in science experiments.

In general, while students were not particularly concerned about being given control over the screen layout, they were most motivated when provided with:

- Choices of levels at which they could operate, so they could start with simpler examples and work towards those with more variables, or more variation within the available variables.
- Choices of assistance levels. On-screen hints were a distraction for students working comfortably with the materials, however they were sometimes essential for students working alone. Nonetheless, almost all students in the study, regardless of ability, preferred to work collaboratively with a friend.

- Immediate feedback in the form of visibly changed conditions on the screen.
- Multiple sources of feedback. However, it was observed that students given graphic and numerical data to work with often overlooked the numerical information.

Comfort and familiarity with multimedia elements and conventions influenced how well Learning Objects were used. Not all students understood how to follow text links to "Help" and were more likely to follow graphical cues. Students, especially the literacy-challenged, liked the use of sound to alert, add effect and provide assistance. They responded with varied success to visual complexity so that some helpful features of Learning Objects were overlooked by students until they were pointed out by the teacher.

Pedagogy: Students and Teachers

The third interaction between the three components of the classroom environment from Figure 1 is where teachers and students interact through the pedagogy operating within the classroom.

The taxonomy of Brickell, Kanuth, Freeman, Latshaw, and Larson (2006) distinguishing various levels of interaction between students and the Learning Object resource from fundamental (e.g., images) through combined closed (e.g., videos), generative (e.g., quizzes) to generative instructional (e.g., objects providing feedback) requires more expansion at the upper end if the potential of Learning Objects is to be achieved. Ilomäki et al. (2006) provide an insight into some of the higher level tasks that can be promoted through the use of learning objects including: activating prior knowledge, providing multiple representations of concepts, supporting conceptual change, enabling the visualisation of abstract concepts, simplification of complexity, provision of models and guidance in their use, and support for collaboration.

Various other documents have discussed the impact of pedagogical philosophy on Learning Object design (Atkins, 2003; McRae, 2001; Muirhead & Haughey, 2003), and other authors have discussed the role of pedagogical philosophy in ICT-based learning (Kennedy & McNaught, 1997; Phillips, 1997; Reeves & Hedberg, 2002).

Participating teachers diverged widely in how they finally embedded the Learning Objects into lessons. Some teachers spent time leading into the Learning Object and set clear tasks to be achieved. Others selected Learning Objects thematically related to recent class work but little preparation or integration was evident. Approaches included:

- Using a single Learning Object as the focus of a lesson or lesson series;
- Using a number of Learning Objects as resources for a lesson or lesson series; and
- Using a Learning Object as one of a number of activities within a lesson.

Learning was most effective in environments where teachers provided additional guidance and scaffolding, and where students were able to apply it within Learning Objects. Where the Learning Objects were an integral part of a wider project or series of lessons there was evidence of intended or actual follow-up. In classrooms where little preparation or integration within the wider programme was evident, it appeared that follow-up was unlikely.

The study found four important ways in which Learning Object design influenced its pedagogical value. They parallel the decisions teachers must take when planning a learning experience: the accuracy and depth of the syllabus content, how to fore-ground the learning purpose, the means by which students can proceed through the learning experience, and the choice of an authentic learning context to couch their learning experience.

The content accuracy and integrity of Learning Objects are important, particularly where teachers use the Learning Object as pivotal teach-

ing resources (Kay & Knaack, 2007). Potential concerns for learning are where the Learning Object provides:

- unclear and insufficient information. This is sometimes unavoidable when teachers use the same Learning Object for different purposes. For example, a secondary teacher of a gifted and talented class based a lesson on the normal distribution of results provided by a random number generator within a simulation's algorithm. A primary teacher reviewing the same Learning Object felt the uncertainty created by the random number generator would distract her class.
- an inaccurate representation of important disciplinary concepts. This may occur when visual impact is added by multimedia developers, especially when using cartoon animation, after content accuracy has been checked by content experts. Critical input from content experts, familiar with both the canon of the discipline and the common alternative conceptions that students may possess about it, throughout the entire lifecycle of resource development would avoid this vital deficiency.
- no immediate feedback to confirm or reject student choices resulting in misconceptions being propagated. The study noted examples of scientific misconceptions being fostered, simply because, in the absence of feedback or additional contradictory information, the students imposed an inappropriate mental model that built on prior misconceptions.

Students rely on the learning purpose being transparent and central to the activity that they are undertaking with the Learning Object. This transparency can be enhanced by the use of contextualised information, hints and timely feedback which were all observed to be valuable in directing and affirming student input and understanding. Teachers have a role in monitoring whether students are aware of elements within Learning Objects that provide this.

As with any educational activity, it is essential that motivation is not treated as a goal in its own right, but that success is linked to learning rather than the completion of the activity. Where the challenge of a Learning Object is inextricably linked to the teaching purpose, including the consequences (feedback) navigation, scoring and all other parts of the action, students learn *through* "playing the game." However, where the gaming components are not aligned with the learning aims, then students will circumvent the learning activities in order to finish the game quickly. Again, the lesson content and teacher expectations frame how Learning Objects are used.

Integrity can also be compromised where there is a mismatch between the literacy and other conceptual demands in the Learning Objects. For example, where the literacy demands of the instructions exceed the capacity of the students, then students may guess and succeed without engaging with the learning purpose. To be effective, it is important that Learning Objects are designed so that students can only succeed by demonstrating and applying the intended learning. It is not always easy for teachers to detect this when selecting Learning Objects but by observing how students use them, appropriate questions and help can be provided.

While the learning purpose should be determined by the teacher and supported by the Learning Object, it does not mean that the user should be bound to traverse the Learning Object in a predetermined manner. Some Learning Objects maintained a clever balance between text and graphical information. While they did not appear to impose structure on students, they provided a highly structured learning environment where their success relied upon the way in which students were immediately engaged in making choices, and gained necessary context-specific information through feedback on their input throughout the activity. Where feedback arrived at the point of

need, and in segments small enough for students to assimilate them, the students incorporated them into the next stage of their interaction. This design mimics Boud and Feletti's (1997) Problem-Based Learning approach where students are provided with an initial scenario and need to make decisions. The complexity of the situation builds as they attain more information depending on the decisions that are made at each stage. As opposed to linear activities where students resisted more than one exposure, students voluntarily kept exploring these nonlinear activities in order to master them fully. This would appear to be a sound approach to encourage authentic learning.

INTEGRATION: LEARNING @ THE CORE

The educational environment model in Figure 1 suggests that effective learning arises where the three factors: Students, Teachers and Resources intersect. McCormick and Li (2006, p. 227) regretted how Learning Object design often "assumes that the pedagogy resides within the Learning Object rather than in the interaction of the way teachers fit it into their own pedagogy" effectively decontextualising the Learning Object from its use.

Recognition of the importance of the educational context implies that learning takes place when both students and teachers are at ease with the Learning Objects, there is a shared understanding of the learning purpose and the way the Learning Object is to be used and that the Learning Object fulfils the teacher's need to address the curriculum and the students' need to construct meaning and receive appropriate support and feedback during that process. As long ago as 1995, Peters (cited in Schaffer & Douglas, 2004, p.15) recognised that "objects … will be more like *experiences* than they will be like *things*, much more like *programs* than *documents*, and readers will have unique experiences with these objects."

Students believed that their learning benefited from the introduction of Learning Objects. Learning Object design can accommodate the key elements which satisfy students' needs: challenge, student control, freedom to explore, capacity for collaboration and timely instructions, and feedback on input. The more these elements are satisfied the better is the learning. Learning Objects, therefore, need to exploit their ability to provide students with novel content and learning situations that draw from situated learning opportunities beyond the classroom.

In this study teachers believed their teaching had benefited from using the Learning Objects. Some teachers found that Learning Objects presented new ways for them to view the curriculum or led them to appreciate a wider variety of learning perspectives or prompted them to reconsider their assumptions about teaching and learning. At the same time, a teacher's life is crowded and the value of Learning Objects and their ability to fit into pre-existing programmes and teaching styles must be immediately clear as resources are most valuable when they can be readily matched to curriculum and integrated into learning programmes. As more Learning Objects are produced, this match will be easier. Learning Objects which are rich enough to have multiple uses are particularly valuable.

FUTURE TRENDS FOR SUCCESSFUL LEARNING OBJECTS

There is a need to develop a variety of Learning Objects and assist teachers to choose the Learning Objects that would best suit their needs. The current offerings are a useful start, but a larger corpus of materials, easily accessible, will make them more appealing to both teachers and students.

A synthesis of the results of this study has led to the development of a set of characteristics of a successful Learning Object. These are summarised in Table 1.

Table 1. Characteristics of successful learning objects

Generic	Exploration by students is encouraged.
	Learning Objects are rich enough to allow use on multiple occasions.
	Students are motivated to undertake multiple attempts.
	Gaming techniques, such as rewards and consequences which are relevant to the learning purpose, are used.
	Where appropriate, levels of difficulty are incorporated to provide activities suitable to students of varying academic and literacy levels.
	Instructions are provided when they are needed rather than only in advance.
	A statement of the learning purpose is accessible throughout the Learning Object.
	Learning activities challenge students and are suitably complex while maintaining a simple user interface and reducing literacy demands.
	Timely feedback is provided to students, preferably in multimedia format.
	Students can modify earlier results on the basis of additional experience, or can demonstrate understanding at any time.
	Mechanisms to scaffold student learning are incorporated.
	Students are able to transfer their work to printers or other applications such as *Word* and *Excel*.
Text and graphics	Text-intensive instructions are avoided, especially on initial screens of a Learning Object.
	Graphics, animation and voice support are used in preference to, or in conjunction with, text.
	The amount of text on each screen is limited to six lines or less.
	The need for students to enter their own information is carefully considered and only used where it adds to the learning purpose.
Sound	Sound is available wherever possible, both for information and effect, and to minimise literacy demands.
	Sound can be toggled on and off.
Animation and video	Video clips are distinct and easily interpreted by students.
	Animation is used in preference to video when focus on important features is enhanced by it.

CONCLUSION

Learning Objects remain one resource amongst many that are available to teachers, and may not always be the most appropriate for the task. This study reconfirms previous findings suggesting that teachers' beliefs about teaching and learning influence their choice and use of resources. In practice, the study found that while teachers were eager to exploit new the opportunities offered by Learning Objects, some teachers replicated simple, meaningful real-world activities with Learning Object simulations. Yet both students and teachers repeatedly expressed a preference to perform activities using real materials rather than through computer simulations. This apparent anomaly needs investigation if Learning Objects are to expand, rather than contract, students' experiences in the world around them.

Pivotal to the successful implementation of Learning Objects in primary and secondary classrooms are the teachers':

- ability to access and select appropriate resources using the infrastructure available within the school
- confidence in selecting appropriate Learning Objects to satisfy curriculum outcomes.
- competence to incorporate Learning Objects into meaningful teaching programmes where they can promote student learning in the most effective way
- capacity to adapt Learning Objects to satisfy the individual needs of their diverse classes
- monitoring and evaluation of learning while students are using Learning Objects.

The refinement of design standards for Learning Objects will never make a significant impact on any of these factors. In each instance, the provision of suitable, ongoing professional support within the context of the systemic-school environment will be required. The design of Learning Objects is ultimately not simply a technical issue, but raises many issues related directly to the learning process and environment.

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KEY TERMS

Access (Student and Resource): Access in the sense used in this chapter is not simply how the student brings up the relevant Learning Object onto his or her screen. A Learning Object is accessible when students can easily locate the Object, are engaged by what they observe, can work through the learning opportunities it presents, and, through its use, achieve some desirable learning objective. This process has components, including the hardware, software, connectivity, and regulations within the educational system that provide the student with the physical access to the learning potential of the object. However, accessibility must also recognise the developmental nature of education, for example in the literacy or manipulative loads that are required of students if they are to learn from the Object. Finally, there is an important social equity component of ac-

cess where the Learning Object must be usable by all targeted students in ways that recognise, for example, individual student's culture, gender and special needs.

Pedagogy (Teacher and Student): Pedagogy has been used in this chapter to include all aspects of the ways in which teachers create learning environments in the classroom through an appropriate alignment of instructional strategies and styles of the teacher and the Learning Object. As such pedagogical concerns include all the choices that affect how the students can manipulate the learning materials to construct and reconstruct their conceptions in the classroom. In this manner it will include the social aspects of the learning purpose as conceived by the teacher and the students, and the way in which the resource either facilitates or hinders that purpose. While the social construction of learning is at the heart of the pedagogy, it cannot be seen in isolation. Also important is the manner in which the learning context is developed and directed. The context is the environment in which learning occurs and a learning environment is created around the resource by the programming of the teacher and the reactions of the students. The pedagogy will also include a component where the physical and cognitive skills of the students are recognised by the way that the teacher and the resource draw on them to facilitate the learning outcome.

Selection (Teacher and Resource): Selection in the sense used in this chapter is more than a teacher picking a lesson activity. It is a complex sequence of choices where the teacher must locate a source of Learning Objects, evaluate the range of available Objects for the intended purpose, and then decide on the viability of integrating that Object into a multifaceted teaching programme. Each step of this selection process implies evaluative judgement. In involves an evaluation of the physical availability of necessary software and hardware, as well as passwords and permission to download onto the system infrastructure. Selection involves reflective judgements by the teachers of their own intellectual skills in areas like Internet searching and understanding the presentation of metadata. It also involves an emotional response from the teacher that may be dependent on subject or computer literacy, available time, a sense of empowerment—or disempowerment, and a host of personal factors.