

Enhancing Learning Through Dialogue and Reasoning Within Collaborative Problem Solving.

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Abstract

A co-constructivist view of learning places a significant emphasis on classroom interaction and social learning. 'Students prefer an active to a passive role; they prefer transaction to transmission; and they want to learn through a range of activities' (Morgan and Morris, 1999). Technology and design has the potential to provide opportunities for students to be active in their learning: to discuss, to think, to plan, to make decisions, to reflect and apply. Consequently, teachers need to provide classroom learning environments that will promote learner empowerment through collaboration, interdependence and problem solving dialogue.

The present study focuses on the use of dialogue as a tool for thinking and reasoning within collaborative problem solving. Two groups of students were involved: a PGCE group of student teachers (Case Study 1) and a group of eleven-year-old primary school pupils (Case Study 2). Each group was operating within the context of a normal classroom setting. Stories were used to provide a context or 'natural setting' for practical problem solving. In both case studies the role of the tutor was to encourage learner centred dialogue, experimentation and active engagement with the problem(s).

PGCE students were asked to complete two questionnaires, one prior to the activity and one upon completion. Primary school children completed only one evaluative questionnaire at the end of their activity. Video and audio recordings of both groups were used to provide transcripts that enabled a more detailed conversation analysis to be undertaken. This analysis showed the importance of interaction in learning and the kind of talk and collaboration that is needed to facilitate such learning. The extent to which the PGCE student teachers were able to identify and use the range of higher order thinking skills embedded within technology and design, problem solving activity was also investigated.

Analysis of the data revealed significant changes in PGCE student perceptions of the contribution of technology and design to the development of children's thinking. The post-task questionnaire indicated heightened awareness of the qualitative nature of the task, especially the value of

collaborative learning and dialogue within problem solving. The primary school pupils identified fully with the story context, and it was this that fuelled their high levels of interaction and collaboration. Through a careful use of language, at critical incidents in the problem solving process, the teacher was able to scaffold pupil learning and provide the kind of assistance that enabled the pupils to achieve at much higher levels than they would have done unaided. The importance of learning through active engagement, using a problem solving dialogue, was highlighted in both case studies.

Key words: co-constructivist, interaction, learner empowerment, dialogue, collaboration, active engagement.

Rationale

Traditional views of education tend to view education as a 'system', one that is unidirectional and predetermined, rather than as a challenging interaction between teacher and pupil, and pupil and pupil. The former places an emphasis on performance and standardised tests. The latter places an enhanced emphasis on learning, and pupils being equipped for the tests of life i.e. able to handle change, uncertainty and the complex demands of living and working in the twenty first century. Social constructivist theories depend on a view of education that places language and interaction at the heart of the learning process. In this context, Vygotsky (1978) held that talk was not about the transmission of facts, but rather its significance was in the communication between the developing child and others with more knowledge. For van Lier (1996) such 'interaction is the most important element in the curriculum'. 'Learning arises not through interaction, but in interaction' (Ellis, 1999).

McGettrick (1996) defined education as 'a conversation from generation to generation about matters of significance'. Such matters of significance need to encompass what Claxton (1999) suggests as a new classification of the three Rs: Resilience, Resourcefulness and Reflectiveness. This conception of learning necessitates building learner empowerment that can only be gained through collaboration, problem solving, interdependence and a sense of purpose, negotiation and meta-learning. Costa (2003) argues a case for utilising habits of mind as the engines of



effective thinking, and lists sixteen such 'ground rules' to be nurtured through a process of questioning and reflection. For Costa, a habit of mind means having a disposition to behave intelligently when confronted with problems and facing uncertainty.

It is interesting that Rousseau (1780) claimed in his developmental theory that 'interest, intellectual development and correct habits of thinking' could be encouraged through 'solving practical problems in their natural setting'. Dewey (1929) used the term 'reflective inquiry' and placed considerable emphasis on 'method', the process by which conclusions are reached and problematic situations resolved. For Dewey, meaningful learning developed mainly through engagement and interaction with real life problems that the student found interesting and challenging.

Research study

This research study has a significant focus on pupil learning. In particular, the impact of classroom interaction and language use in creating and developing opportunities for learning with understanding. It is based on two independent groups of students; a PGCE group of student teachers and a group of primary pupils, aged eleven years. Both groups engaged with problem solving activity that arose from two different story contexts. The context in each case provided a natural setting to engage students in active learning. In preparation for the problem solving activity, all students were familiarised with the rules of engagement and participation for co-operative group work (Johnson and Johnson 1990). Figure 1 shows a holistic approach to teaching and learning that integrates context (natural setting) and method (process). Context and wholeness are conditional for meaningful learning (Bruner, 1966).

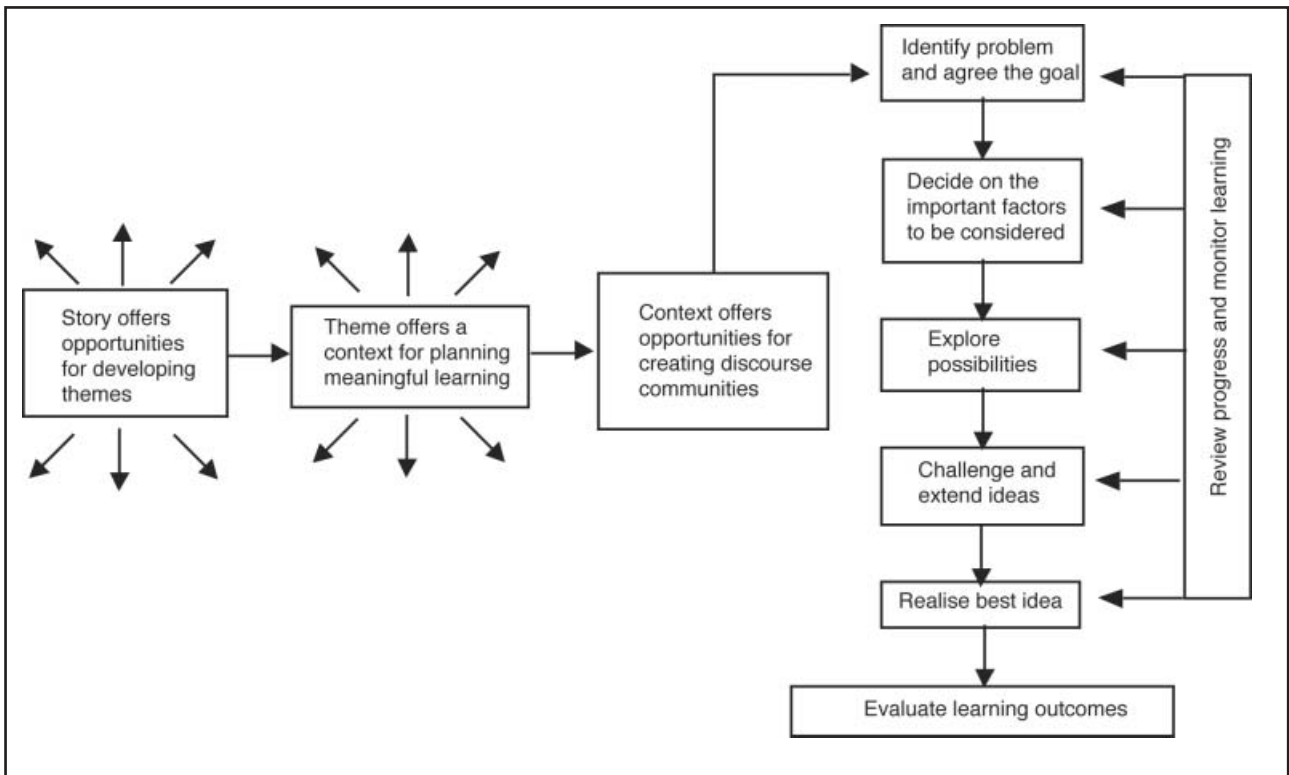


Figure 1: A holistic approach to teaching and learning.

An elaboration of this model (Figure. 2 Appendix 1) shows the kind of evaluative questions students were encouraged to use and develop within a problem solving discourse community. The distinctive metacognitive emphasis helped students to take greater control of their own learning as they engaged in the problem solving process of questioning and reflective inquiry. In using the language of learning, students were being encouraged to develop individual ways of questioning and problem solving (habits of thinking). Generating key questions such as those listed in Figure. 2 also helps to create the criteria for self-evaluation and assessment. In the process of solving real problems, pupils are becoming better learners and better at developing their own learning power and learning stamina (Claxton, 1999). Building learning power means acquiring the skills, attitudes and dispositions needed for engaging creatively with problems and problematic situations. The challenge for the teacher then is to create a learning culture in the classroom that will build upon the interests, creativity and knowledge that the pupils bring to the learning situation.

Data and methodology

The study set out to consider the effectiveness of the following in developing a learning orientation with students:

- The use of a story to provide a context for authentic design and problem solving activity.
- The use of co-operative small sized groups as a discourse community that fostered interdependence and learning success.
- The ways in which the teacher's choice and use of language within an interactive mode creates opportunities for learning and creative activity.

Stories are a rich source of curriculum content, and often a balanced topic web can be planned around a single, well-chosen story. A story has the power to fire children's imaginations, stimulate their creative energies, and engage them with real world issues. The holistic nature of stories enables pupils to make connections and gives meaning to knowledge and understanding. Two stories are used in this research study. One with a PGCE student group, Case Study 1, and the other with Year 7, eleven year old primary pupils, Case Study, 2. The second case study developed from the researcher's involvement with a European Comenius project (LaTech, 2002-2004), which analysed the contribution of language to children's technological understanding.

Case study 1

The research tutor had a class of 27 female PGCE students for primary technology over a two-day period. None of the graduates had a GCSE in Technology and Design and only five had studied Physics to that level. On a technology competence scale of 1 – 6, where 1 represented very competent and 6 not competent, twenty-four entered a score of 4 and greater. Five questions were asked at the beginning of the course and the same five questions were asked at the end. A follow up recorded discussion and a separate more detailed questionnaire was used to obtain further information on the thinking and learning process the students had experienced over the two days.

The story identified a situation experienced by some young people when they purchased a box of chocolates. To their surprise they discovered that not all chocolates were the same diameter, a few were a rogue size. Reflecting on that situation, and how it may have arisen, the PGCE students increased their awareness of quality control procedures within industrial organisations. They were also encouraged to consider briefly, such related concepts as predictability, equality, sameness, and fairness, and how the story could be used to develop an understanding of such concepts with children. The students viewed a slide sequence that showed some of the control procedures adopted in a local lemonade factory when, for example, a bottle is detected with a top missing or the level of the liquid is lower than it should be. This was followed with a short discussion.

For the purposes of this problem solving activity, ping pong balls were used to simulate the rogue sweets, and marbles represented normal size sweets. Using the materials provided, students had to resolve this situation and design a quality control procedure that would separate out the ping pong balls from the marbles with 100% efficiency. This was quite a challenge for students who had little or no experience of this kind of problem solving activity. The students were told that this would be a collaborative activity and that they would be put into groups of four to work together, learn from one another and generally solve the problem. A limited range of tools and materials was made available for solving the design problem and students were given a few short demonstrations on how to use the cutting tools safely, and with care.

When asked at the outset of the two day course what they thought was meant by primary technology, typical answers included: an introduction to production; learning about basic mechanics, and anything to do with science. All twenty seven

students agreed that it was an important area of the curriculum, with reasons given including: it was useful in the home; the knowledge element underpins science; we need to know about everyday gadgets; it prepares young people for the future. When asked to give an alternative word for primary technology, five said science, twelve said construction or making, four said designing and six remained blank. Typical primary school technology activities listed included: making a land yacht; making a lego car; making a circuit with a battery and bulb and making things.

At the end of the two day course there was a qualitative difference in the answering. Enhanced conceptions of primary technology included reference to: thinking, planning, discovering, problem-solving, inquiry based learning. Reasons given for rating technology as an important curriculum area included: it involves planning, reviewing and implementation skills. Teamwork, development of thinking skills, heightened self-esteem and confidence were also referred to. More significantly, alternative words for primary technology included: thinking, challenge, success, minds on learning and creativity. This time no blank spaces were recorded. Classroom activities that now could be envisaged included: story characters, events or dilemmas, play activities for nursery school children, party activities and games and fun toys. There was an association of technology now with creativity, happy and fun type activities. There was also a definite mind shift in favour of an activity that was now 'do-able' and one that had built in learning power.

All twenty seven found the problem solving activity challenging, but fun. All were pleased with the final practical outcomes, suggesting improvements and modifications. It is interesting that when asked was it a serious activity, thirteen said it helped to develop critical and creative thinking but the other fourteen seemed to have some difficulty reconciling a fun activity with a serious activity. When probed further on this they did go on to say that the nature of the activity involved collaborating and interacting, discussing and planning, reasoning and decision making, and that all these were important for meaningful learning to take place. One student teacher, who experienced personal difficulty in handling the uncertainty of open-ended problem solving, still seemed to have a hang up about wanting to be viewed as a confident practitioner or 'omniscient' in the classroom.

There was particular reference to the value of cooperative group work and the opportunity it afforded students to talk, think, plan, reason and review their progress. The nature of the interactive

decision making experience tended to keep students focused on the design activity and the inherent problems they confronted. Throughout the activity students encouraged and facilitated each other's efforts as they worked collaboratively. The students exchanged ideas, provided explanations and clarifications, and sought to give reasons for their thinking. There was also individual accountability and ownership of the problem solving activity. A significant majority (twenty one students) indicated they would have had difficulty resolving the challenge on their own or even getting started. Discussion they felt was vital to productivity and the development of a creative solution, especially within open-ended problem solving. Where positive goal interdependence did not exist in groups, the groups would not be truly co-operative (Johnson and Johnson, 1990).

The problem solving challenge encouraged exploratory talk and habits of thinking that enabled the students to infer, hypothesise, use their imagination, think aloud, reason and fine-tune their ideas (Mercer, 2000). The story context provided a natural setting for a real problem solving experience, with real opportunities for students to engage in reflective inquiry. Equally important was the view that the students had been active in their groups, generating and applying knowledge in response to the demands of the task. Twenty six students felt that being actively involved in this way was the real value of cooperative, small-group learning. Supporting research shows that other benefits from collaborative learning include more time on task, increased motivation and perseverance with tasks, and improved communication skills (Hunt et al, 1994).

Extract 1 (Appendix 2) shows a part transcript (turn 9 - turn 38) used by one of the PGCE groups. A conversation analysis reveals how this process of reasoning with language enabled the group to construct a common knowledge and understanding in pursuit of their goals.

Evaluative written comments at the end of the two days showed a change in conception towards the value of this activity in developing higher order thinking skills amongst pupils.

'Technology has proved to be entirely different to what I had previously thought. It is not just about machines and computers, but rather it is about putting your ideas together to find the optimum solution to a given problem. It is about designing something and following that through, so that the theory is put into practice...it is also very satisfying to see your work develop from a plan or a drawing to a working model, and for everyone in the group to be pleased with it.' (PGCE student).



Case study 2

The pupils in the Year 7 class were undertaking a different kind of collaborative project on birds, having read a RSPB Bird Watch survey report in a local newspaper. Pupils were encouraged to talk about and create their own bird stories using the different sources of information they had discovered. They knew, for example, that different types of birds visited the feeder outside the classroom window each day. Lisa, a pupil in the Year 7 class, thought it would be a good idea to invent a reliable way of knowing when a bird was at the feeder. If she had information on the type and frequency of birds using the feeder, she could compile a computer database to help her write her own 'bird watch' report. Jon and Paul offered to help her with the 'birdfeeder problem'. They thought it would be really helpful to have a bulb or some sort of indicator system inside the classroom to let her know when a bird had landed at the feeder. Lisa could then identify the bird from the classroom window and make a record of it.

As a group, the pupils decided to utilise a balance mechanism, with the bird food at one end and a counterweight system at the other. The intention was for a bird to land at one end of the mechanism and for the other end to rise slightly and close a switch. The closed switch would complete a circuit and light a bulb in the classroom. The three pupils in this particular case study had no experience of working as a group, but did have some limited experience of collaborative group work with the tutor on an earlier project. This kind of collaborative problem solving where pupils engaged in dialogue to talk through their ideas was relatively new to the group. The tutor's main pedagogic goal was to encourage pupils to be flexible and open minded in their thinking and his use of language supported that goal. Extract 2 (Appendix 3) shows how the tutor supported and encouraged the pupils in their thinking through sensitive and responsive questioning that acted as a scaffold in the thinking process.

It was important that all ideas in the group were considered and that the collective thinking remained coordinated and focused. This was a complex and ambitious problem for this novice group of pupils. Left on their own the challenge would have proved insurmountable. Through careful and sensitive use of language, the tutor assisted the pupils by giving structure to the problem and, guiding the collective thinking at critical incidents. This enabled the group to remain on task, focused and clear as to what was possible with the resources available. This is a managed learning situation and the teacher played a key role in determining the quality of the learning outcome(s). New ways of working in the classroom need to be developed to scaffold and model learning in

ways that assist the transfer of responsibility for such learning from the teacher to the learner (Rich, 1993).

Through a process of dialogue and 'interthinking,' (Mercer, 2000), the pupils were learning that there was no one 'right' answer to practical problems and that different solution pathways could be explored. They were also finding out that some ideas were better than others and that all ideas could be modified through argument and negotiation. The use of 'exploratory talk' in the joint activity ensured that all ideas had to be clear and explicit for them to be understood and jointly evaluated. Collaborative learning provided opportunities for practising and developing ways of reasoning with language that encouraged the pupils to feel in control of their learning, active and reflective.

The pupils have the capability to redesign the birdfeeder. To be successful, however, they need to be more systematic and focused in their approach to thinking through the different aspects of the challenge. They are at the edge of their learning and a sensitive teacher will recognise this point. The skill and professionalism of the teacher lies in the timing and quality of the intervention needed. It is at such critical incidents that pupils need the support and encouragement from the teacher to scaffold and structure their thinking. The real danger is that in the excitement and frenzy of the group activity the pupils give themselves insufficient time to explore the inherent value in each of the contributions being made. In giving themselves insufficient time to explore, challenge, extend and review their collective thinking, the pupils are in danger of giving way to 'premature closure', or 'superficial attention', and simply opting out, claiming 'I can't do this' or wait for teacher to do it for them. With careful and sensitive teacher intervention and restructuring, such a situation can be turned around to offer pupils a much more profitable learning outcome. The critical and creative thinking of the pupils needs to be matched by the creative thinking and professionalism of the teacher.

Conclusions

Learning in each of these separate case studies resulted from problem solving activity that was grounded in a real world context. The learning experience was collaborative, first-hand and extended over a period of time (two full days for the PGCE students and one day (five hours) for the primary pupils). The students were intrinsically motivated by a challenge that was relevant and of interest to them. In the process of solving a problem, the students were acquiring a grasp of the underlying concepts through learning how to operate with them. This process of reflective inquiry encouraged them to



identify problems, search for solutions and reach conclusions. This process elicited their curiosities and sense-making skills. Understandings were co-constructed through dialogue to enable the participants to undertake the tasks (Lantolf, 2000). The PGCE students identified fully with the problem context, and the challenge it presented, and did not perceive it to be a low level activity. In each case study the participants had to cooperate and use talk to solve the problem(s). They had to reach a shared understanding of what was required, share and evaluate relevant ideas, negotiate and agree a way forward, develop, test and modify a workable solution. Rousseau's enthusiasm for practical problem solving stemmed from his belief that interest, intellectual development and correct habits of thinking could be encouraged and developed through engagement with real problems.

The conversation analysis highlighted the key role of the teacher in creating opportunities for learning at critical incidents in the problem solving discourse. Through sensitive intervention and careful scaffolding of student thinking, learning with understanding was enhanced. This is a 'managed learning situation' engaging teacher and learner in an effective teaching and learning partnership. Student teachers and experienced teachers need to have an increased awareness of the potential of their language use to facilitate pupil learning, and feel comfortable in matching language use to pedagogic goal within lessons (Walsh, 2003). Language use needs to adapt to the demands of a particular learning situation, and be appropriate to that situation. This is a particular challenge within technology and design where students can be engaged in such diverse activities as design and problem solving, research, manufacturing, experimental or investigative activity, systems design, ICT, in response to a high complexity project brief.

All classroom communication is a conversation and teachers need to encourage pupils to verbalise and visualise their own design thinking. They must resist 'filling in the gaps' and answering for them. When encouraging interaction we need to encourage more of the ragged type and give students sufficient time to think for themselves. By smoothing over the discourse for them, the teacher is unintentionally causing pupils to engage in 'premature closure' or 'inadequate monitoring' of their learning. It is only through engagement with real problems and having opportunities for reflective inquiry, that students can be challenged to develop habits of thinking that enable them to face unfamiliar and uncertain situations with increased confidence. In utilising habits of thinking the students are constructing and adapting strategies to meet the demands of a particular problem solving situation.

It is important that students be given time at the end of an activity to reflect on the effectiveness of their own thinking and share this within and across groups. They need to be given an opportunity to reconsider what evaluative questions they asked during the problem solving process, what strategies they used, what worked and didn't work, how they felt as they were solving the problem, what were the high spots and what were the lows, what energised them and what slowed them down. This is what Dewey (1929) called 'the fruit of the activity'. The fruit of the activity is what students remember from the learning experience. It is this knowledge, or creative capital, that students acquire through doing that has the potential for transfer to new and unfamiliar learning situations.

In both case studies the students took on challenging tasks. The learning was high-complexity learning that entailed dialogue, analysis, reflection and collective responsibility. There is a tendency, mainly due to restrictions of time and an over emphasis on content, for some school learning experiences to become low complexity, short term, and not requiring judgement. The teacher needs to provide a learning culture which is supportive and allows students to be unsure, tentative, doubt, question, challenge, make mistakes, change their minds and change their solution paths. When asked about classroom learning, young people say the most effective classroom activities are those that involve 'research, talking to other pupils, class discussions, demonstrations, practical work, group work and one to one help from the teacher' (Curtis, 2000).

When asked what they enjoyed most about the problem solving experience the primary pupils said 'helping Lisa solve her problem', 'watching the bird land and the light working', 'working as a team'. The PGCE students made similar reflective comments: 'demonstrating to each of the other groups how their solution worked and learning how the others solved their problems', 'demonstrating success and getting clapped for it', 'a feel good factor from a real sense of achievement' Assessment in both situations was self assessment and peer assessment. Students were integrating their conceptual and procedural knowledge at the same time as they were learning to do, and learning to work collaboratively.

Both sets of students were successful in their problem solving and co-operated well within their groups. This was evidenced in the way they managed the turn taking in the discourse analysis. The rules of engagement and participation were embodied in their group practice and contributed significantly to the quality of their learning outcomes. Research undertaken by Gillies and Ashman (1996)



with Grade 6 children, found that the children in the trained groups were more co-operative, productive, and obtained higher learning outcomes, than the children who worked in the untrained groups. Both case studies in this research paper support these findings. The analysis also shows that curriculum development needs to give much closer attention to teacher development, especially the use of language and talk in the classroom.

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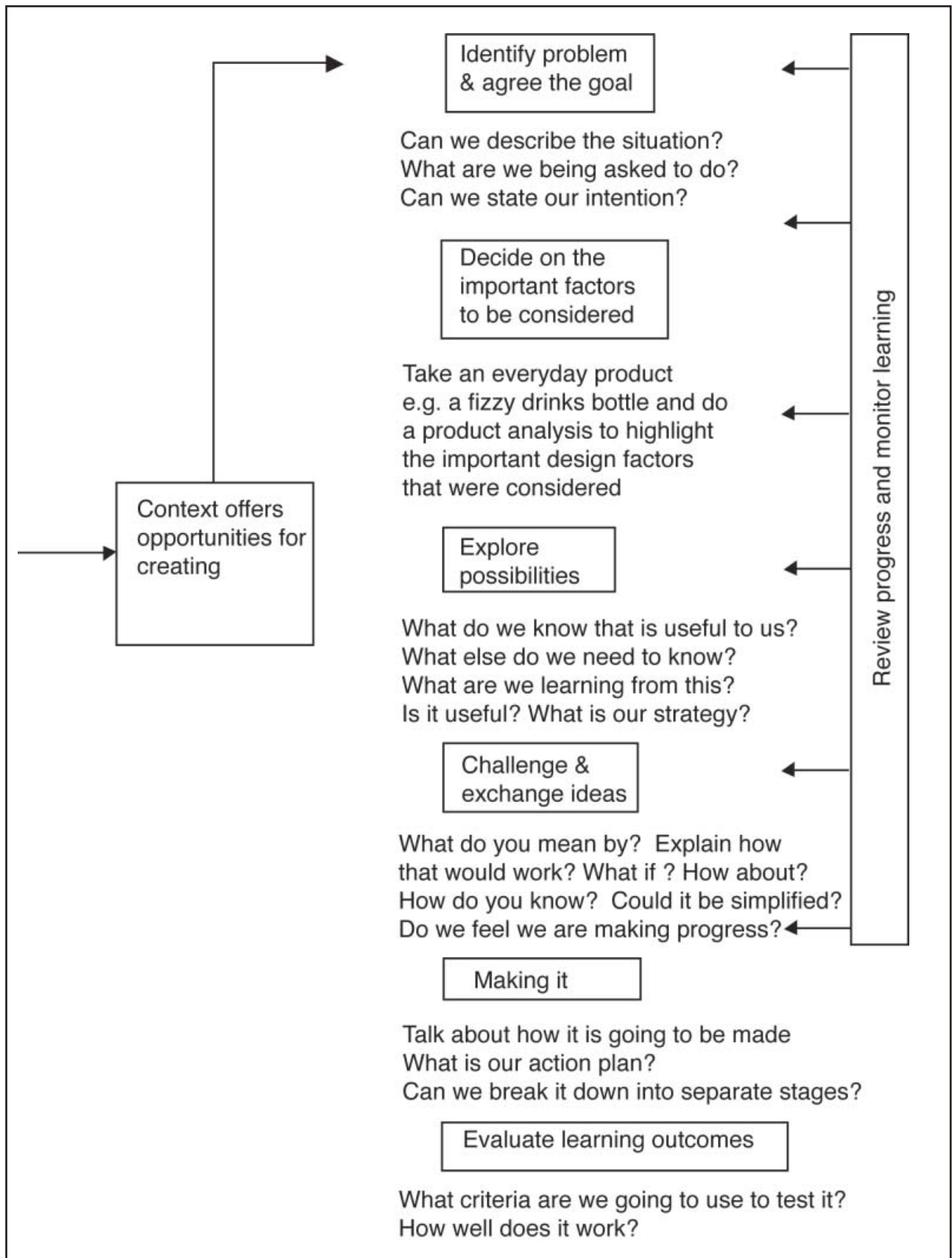
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Appendix 1 (Figure 2): Creating a problem solving discourse community.
Planning, monitoring and evaluating learning effectively

Appendix 2 (Extract 1)

This extract shows a part transcript (turn 9 - turn 38) used by one of the PGCE groups. A conversation analysis reveals how this process of reasoning with language enabled the students to construct a common knowledge and understanding in pursuit of their goals.

- 9 C What are we being asked to do here?... how are we going to do this?... don't have a clue
- 10 M Find some way of sorting them out... they are mixed up and we have to separate them (holding a collection of marbles and ping pong balls (m&p's))
- 11 C They are different weights... the ping pong balls could float... I know... throw them all into a bucket of water... ping pong balls will float... marbles go to the bottom
- 12 J Good idea... pity there's no water... we could then fish them out
- 13 M But you would have to dry them all...
- 14 A Do you know that when you roll them the marble goes in a straight line...
- 15 C it goes faster as well
- 16 J Probably goes further too...
- 17 C The ping pong ball goes all over the place (starts playing with the m&p's on the table top)
- 18 M But how are we going to use this?... we need to make something that will sort them out
- 19 C What materials do we have?... is that all we can use? (pointing to the materials set out by the tutor for this activity)
- 20 J Yeah, we have 2 lengths of wood (has brought some materials over to the group)... some manila card and PVA glue... we have to get a sorter out of that...
- 21 Tu Think about other situations that you know of that make use of sorting systems... where are they used?... what are they used for?... how do they work?... do you think that would help?... you do know about these things... (use of questions to inquire and extend thinking)
- 22 A OK, let's think about this... what are we talking about?... we sort things out in PE, in games... or about the house...
- 23 C You can sort money for a start... I do street collecting for a charity at Christmas time and all the money from the collecting boxes is put into a sorting machine... it's amazing... it just sorts all the coins into different plastic bags... it's cool
- 24 M How does it do that?... do you know how it works?...
- 25 A I'm not sure... you put the money into a hopper type thing, switch it on and then there are levers and things that move and the coins just seem to know where to go and fall into different bags...it's noisy, but very fast. I was amazed at the speed... the coins went into the right bags every time... I could have just stood and watched it... it was amazing.... but that would be too complicated for us...
- 26 C I have worked in a garden centre and I have seen people using a riddle... riddling soil...(demonstrates with her hands)... it's circular with a wire mesh on the bottom and only the fine soil gets through... if we had something like that... all the coarse bits and stones are then tossed to the side... I have seen farmers use a bigger type for separating out small potatoes from the bigger ones... we could do something like that



- 27 J Right enough my mum has used a sieve... same sort of thing... for dusting fine flour on to a cake... you can also use a dredger to sprinkle sugar... something like that would be good....
- 28 M I think we are onto something here... sounds a lot less complicated than the money sorter, but we need to think about how we are going to do it
- 29 A If we poured or dropped the balls into a small container (uses her hands to demonstrate a square shaped storage hopper) then the marbles fall through and the ping pong balls remain
- 30 C We need to catch the marbles when they fall through... we need some form of container or another box or something (makes a counter challenge, also a surprise mental connection, and is pleased with the idea)
- 31 A What does this container (hopper) look like?... could it be a square shape?...
- 32 J It can be any shape really... could be a box with no lid and just holes in the bottom... in fact we could use the compass cutter for that...
- 33 M That compass cutter is too difficult to use... I was trying it earlier
- 34 C It might be easier just to have an open box with four sides... and we could have a lattice type bottom.... we could cut narrow strips of card, weave them together like latticework and use that....
- 35 A Lattice... you mean (and draws a lattice pattern on paper and gets confirmation)... yeah that would do... and attach the ends to the side of the box (makes another sketch to confirm this)
- 36 C If you wanted to be really fussy then you could stick the tabs to the inside of the box so that they are not seen... leaves the outside for other things... might want to put our Logo on it...
- 37 J Yeah, we could make a logo for it.... this could be marketable... this could really catch on...
- 38 M This is good... this is going to work.... I first thought when he asked us to do this... how are we going to do this? all we really need is a card box, square shaped, and about that deep (models with hands), with some latticework on the bottom... well we could do that... we need to think about the sizes....

Conversation analysis

This PGCE group was engaged in a reasonably 'smooth' verbal interaction. They shared and managed the turn taking well and it was clear that they had taken on board the rules of engagement and participation. Up to Turn20 (T20), the students were verbally 'playing around' with the design challenge and loosely considering different material properties and characteristics (marble is heavier, goes in a straight line, marble is faster; ping pong balls could float). A floating and sinking solution was suggested but then discarded for the reasons stated. The idea was acknowledged at T12 as a good one. Interestingly at T9, student C admits to not having a clue as to how to resolve the problem situation.

The dialogue prior to T20 was 'exploratory', students tended to pick up and develop points the previous student was making. At T21, the tutor (Tu) intervened

and asked the students to think outside the box to other similar 'sorting situations' with which they were familiar. This was a significant 'illuminative moment' when the students were 'scaffolded' in their thinking. At T21 student A followed up this suggestion with reference to sorting things in PE and games, and then other systems were considered and elaborated on T 23 – 27. At T28 there was an expression of confidence: 'I think we are onto something here'. T29 showed signs of a possible solution and this was picked up and developed further by C in T30. A at T31 asked for clarification and offered a suggestion. This was confirmed and further elaborated on by J in T32, by making a suggestion, which M found difficult. Student C at T34 was obviously thinking about the situation and stepped in with a much simpler idea that was acceptable to M, and then came back again at T36 to improve on it with a suggestion that now involved J at L37: 'yeah, we could make a logo for it'. The students were feeling good at this point and



confident enough to suggest that they could possibly turn their solution into a marketable product. At T38 there was a reflective comment which motivated the group to begin considering the practical realisation of their idea.

It is interesting that all the action prior to point T38 had been taken up with interactive discourse that involved suggestion and counter suggestion, clarification and explanation, hypothesis and prediction. Modelling, using the materials at hand, and some sketching, had been used to ensure there was a shared understanding of the problem situation

and how it could be resolved. The students then went on to implement their ideas and even though difficulties and unanticipated problems were encountered in the process, they were able collectively to agree a way forward. The interactive nature of the decision making, and the challenging of different ideas within the group, contributed significantly to the creativity of the discourse community. Individual ideas had to stand up to scrutiny from the group members. There was a feeling that they were 'in this together' and they wanted their project to be a real success, look good and perhaps marketable.

Appendix 3 (Extract 2)

The tutor's main pedagogic goal was to encourage pupils to be flexible and open minded in their thinking and his use of language supported that goal. Extract 2 shows how the tutor (Tu) supported and encouraged the pupils in their thinking through sensitive and responsive questioning that acted as a scaffold in the thinking process.

- Tu We need to be suggesting a height for your wooden supports (needed for the balancing mechanism).... What height do you suggest?...
- 211 Jon Not very high...
- 212 Lisa Better shorter...
- 213 Jon Cut that bit off (pointing to a length of wood and estimating a possible size)
- 214 Lisa If you chopped it you would have enough for the other side...
- 215 Tu Why would you want it as low as that? (challenging Jon's estimated height)
- 216 Jon Because you don't really need it....
- 217 Tu It has to fit inside the ?...
- 218 Jon Birdhouse...
- 219 Paul Which side would be for the bird? (will the bird tray be on the shorter or the longer arm from the fulcrum?)
- 220 Jon the shorter.... the longer would be the heavier.... needed to balance the bird...
- 221 Lisa Yeah, Yeah (confirmation)
- 222 Paul You could have the food inside and then it wouldn't get wet (Paul's attention has turned to the bird food)
- 223 Jon The food inside it? (not sure what Paul is referring to here)
- 224 Lisa We would need to know how much food we could place on the feeder.... We don't want it to overbalance or the light bulb to be on all the time (Lisa reacts to the word food and comes up with another concern but does not follow through on Paul's concern for the food getting wet). Would it be a better idea to have a flashing light bulb or just an ordinary bulb?
- 225 Jon How could we make a flashing light bulb?



- 226 Lisa I don't know...
- 227 Paul Then.... It would have to keep switching on and off constantly...
- 228 Tu The flashing light bulb is an excellent idea.... I am going to let you into a secretSome of the bulbs that we have...
- 229 Lisa They flash (very quick follow through)
- 230 Tu Yes they flash.... when they are switched on and heat up they begin to flash. That's a good idea Lisa.... In the classroom you may not see the bulb when it is ON and a buzzer may be a bit of a nuisance
- 231 Lisa But if it's flashing then you see it if you put another box with a mirror type thing or a piece of card with the word BIRD cut out, then the word BIRD would flash
- 232 Tu Yes, that would be even better ...

Conversation analysis

In this situation, Jon, Lisa and Paul, were tackling a design problem which they managed to solve and solve well, but could not have done so unaided. A video and audio recording was made of this group problem solving experience and the pupils had an opportunity at its conclusion to complete an evaluative questionnaire, and share reflective comments with the tutor. Analysis of the overall transcript showed how the pupils' lack of collaborative problem solving experience was being overcome by the tutor's use of language in a carefully scaffolded response to pupil thinking. The tutor intervened in a sensitive way to 'connect' pupil thinking, prioritise goals and action needed, and prevent the process from stalling, or at worst, stopping. Without this kind of sensitive intervention at such critical incidents, the final outcome would have been very different, and the learning would not have been as secure as the end discussion reflected. Through the use of language the tutor was modelling for the pupils an appropriate way of thinking and an appropriate approach to practical problem solving.

Other more specific instances of the modelling and scaffolding process used by the tutor are visible in this extract. When the tutor asked in T210 'what height do you suggest?' there was some non-technical use of language in response: 'not very high', 'better shorter', 'enough for the other side'. In T215 the use of 'why' in the tutor's question elicited the use of 'because' in the pupil's reason. 'Why would you want it as low as that?', 'because you don't really need it'. Pupil responses were not full responses but their reasoning was visible in the exploratory talk and was sufficient to make sense. In this instance the tutor was not prepared to simply take the first contribution the pupils offered, but looked for clarification and some extension of it as shown in subsequent turns. The nature of this

interaction, and the pupil decision making it contributed to, has been called 'pushed output' (Swain, 1996). This type of learning partnership builds on the Vygotskian (1990) principle of incremental learning, and Bruner's (1990) idea of assisted performance. Knowledge was being co-constructed and shaped by participants through dialogue (Lantolf, 2000).

Understandably, the pupil dialogue within the joint activity did not always flow smoothly and tended to be broken up, with pauses and definite breaks in between. It may appear a bit 'ragged' and somewhat uncoordinated, but 'activity flow' and coherence only comes from the experience that is gained through active participation and learning to learn. To the inexperienced problem solver, the use of a particular word in the discourse has the potential to cause the collective thinking to take a sudden change of direction. The word food in this extract was associated with extra weight on the balancing mechanism T219, T220, and at the same time as something that needed to be kept dry T222. Lisa made a further connection between food and the indicator system, and very quickly the thinking took a particular steer towards the need for a flashing indicator system and how that could be achieved.

The group did remain on task, they did produce a satisfactory design solution, and they were delighted with the outcome, 'it works really well', 'the birds would like it', 'it is what we designed'. When asked what they were least happy with, they collaborated to write, nothing, we are really pleased with it



