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An Authentic Learning Environment in a Design and Technology Subject for Preservice Primary Teacher Education Students ®

Ian Ginns, Campbell J. McRobbie, and Sarah J. Stein

Centre for Mathematics and Science Education

QUT - Kelvin Grove

Victoria Park Road

Kelvin Grove QLD 4059

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Abstract

A major emphasis in design and technology curriculum programs for primary school is the engagement of children in hands-on construction of technological artefacts. The children are expected to use design processes in an environment that may resemble, in various ways, the environment that designers and engineers work in. The concept of authentic learning environments may be used to describe such practices and contexts. This paper describes an investigation, using an interpretive research methodology, into preservice primary teachers' views of the learning environment established during their participation in a design and technology subject that included, as key components, an introductory, structured sequence of learning experiences followed by work on an open-ended technology project. Students enrolled in a one-year postgraduate teacher education program were the informants in the study. Insights into students' views about the learning environment were obtained using survey instruments, interviews, field notes and a Repertory Grid. Additional insights were obtained by videotaping and audiotaping the activities and discourse respectively of focus groups during practical sessions. For selected cases, the paper examines the reasons underpinning major changes in their views of the learning environment. An analysis of the influence of the design and technology subject and learning environment on students' thinking about teaching technology in the classroom is also presented in the paper. Implications of the findings for the preparation of preservice teachers in the key learning area of technology are discussed.

Introduction

The document *A Statement on Technology for Australian Schools* (Curriculum Corporation, 1994, p. 3) has described the word technology as being "a generic term for all the technologies people develop and use." Technology embodies the idea that products and processes designed to meet human needs are outcomes of the "purposeful application of knowledge, experiences and resources." The statement also suggested that technology programs in schools should consist of activities and tasks that enable students to "build on their experiences, interests and aspirations in technology; show how ideas and practices in technology are conceived; take responsibility for designs, decisions, actions and assessments; trial their proposals and plans; and take risks when exploring new ideas and practices" (Curriculum Corporation, 1994, p.6). These suggestions imply that a major emphasis in technology programs for schools must be placed on the creation of suitable learning environments and contexts in which students have the time and space to immerse themselves in design practices needed to construct, and in the actual construction of, technological artefacts. Classroom teachers, therefore, must be prepared to establish learning environments that foster such capabilities and 'risk taking' in their students.

Ideally, students should use design processes and undertake the construction of artefacts in learning environments that may resemble, in various ways, the everyday environment that designers and engineers work in (Roth, 1998), where the focus of activity is knowledge building within a community of practice (Roth & Bowen, 1995; Scardamalia & Bereiter, 1994). The concepts of authentic learning environments and authentic practices may be used to describe such contexts and practices (Roth, 1998). Roth has proposed that five conditions pertain to such environments - "1. Problems are either ill defined, or defined so loosely that students can impose their own problem frames; 2. Students experience a sufficient level of uncertainty and ambiguity in finding solutions; 3. The curriculum is predicated on, and learning driven by, students' current state of knowledge; 4. Students experience themselves as part of a community in which specific practices and resources are shared and scientific and technical knowledge are socially constructed and; 5. Students can draw on the expertise of more knowledgeable others, whether they are peers, teachers, or outside experts."

A learning environment in which primary school children can play is fundamental to designing activity according to Davies (1996). He noted that when children designed, in company with a professional designer, there were similarities in the approaches used by both. Davies contended that young children and professional designers have much in common. For example, children learnt through play to interpret their mental images by manipulating and rearranging objects in space, used language to discuss their mental images of possible solutions, used drawings and modelling materials to visualise their ideas, and used personal knowledge. These processes were essentially the same as those used by designers with the added criterion that designers work on 'fuzzy' or ill-defined problems. Davies (1996, p. 58) advocated that children should engage in "real design projects with real designers" so that they can integrate understandings and design skills and can draw on the expertise of a knowledgable others.

Authentic contexts are, therefore, "real life" (or at least life-like) contexts that provide the bases of rich and purposeful experiences needed for design tasks (Davies, 1996; Kimbell, Stables, & Green, 1996; Roschelle, 1992; Roth, 1998). Conclusions about enhanced learning through organising activities within authentic contexts have been made in the case of technology (Fritz, 1994) and a growing number of studies have documented positive outcomes of programs in which authentic technology contexts have been established, for example, Barak, Eisenberg, and Harel (1995), Davies (1996), Gardner (1994), Hill (1998), Hill and Hannafin (1995), and Ritchie and Hampson (1996). Provision of opportunities in which students can negotiate such contexts and design tasks enable students to experience personal relevance and commitment to learning thus contributing to the building of technology learning communities (Prawat, 1996).

How can we probe students' personal views of the learning environment and changes in those views? Shapiro (1996) studied changes in preservice teachers' thinking about the nature of scientific investigation, as a result of engagement in an independent investigation in science. One method of probing change was a Repertory Grid developed from interview data collected in a pilot study. The Repertory Grid consisted of 15 bipolar Constructs (representing terms and phrases used by students when describing an investigation) and 12 Elements (a list of typical experiences in the conduct of an investigation). Participants in the study completed a sheet of constructs rating each of the 12 elements separately.

It is suggested, on an analysis of the Elements and Constructs devised by Shapiro (1996), that both may describe various attributes of an authentic learning environment. For example, Constructs such as *Creating my own ideas - Just following directions,* and *Challenging, problematic, troublesome - Easy, simple* reflect respectively the conditions that problems in authentic contexts are ill-defined (compared to closed design briefs), and the uncertainty and ambiguity of solutions (compared to easy or straightforward solution pathways) (Roth, 1998). Similarly, Elements such as *'Improvements must be made to the original design of the investigation' and 'The investigation does not run smoothly'* also reflect respectively the conditions that problems in authentic contexts are ill-defined and the uncertainty and ambiguity of solutions (Roth, 1998). A Repertory Grid modelled on the one prepared by Shapiro (1996) may be a useful method for observing fine-grained changes in students' views of design and technology learning environments.

The main aim of the study was to investigate changes in preservice teachers' views of technology and technology education as a result of their engagement in a design and technology course unit (subject). It was intended that the design and technology course unit be implemented in a learning environment that was authentic in context, embodying authentic practice, and drawing upon students' existing knowledge and expertise. Therefore, the objectives of the study were:

- To investigate changes in preservice teachers' views about the learning environment in which the design and technology course unit was conducted;
- To examine the effects of the learning environment on preservice teachers' perceptions of technology;
- To investigate the effects of the learning environment on preservice teachers' views about teaching technology in the primary school classroom.

Methods and Techniques

An interpretive research methodology (Erickson, 1998) was used so that the researchers could understand the thoughts and actions of preservice teachers as they engaged in a design and technology course unit. The criteria of trustworthiness, authenticity and the benefits of the hermeneutic process (Guba & Lincoln, 1989) were used to monitor the quality of the interpretive inquiry.

Informants

The informants were drawn from a cohort (130 students) enrolled in a one year postgraduate preservice primary teacher education program. The cohort consisted of students representative of a range of undergraduate backgrounds such as the humanities, arts, performing and visual arts, psychology, business, architecture, and science. The gender distribution was approximately three female students to one male student.

Preservice Course Structure

Part of the preservice teacher education course required the informants to study two compulsory, combined course units in mathematics, science and technology education, one course unit in each semester. The technology component of the second semester course unit provided the teaching and learning context for this study. Contact time with the cohort of preservice teachers in design and technology consisted of a lecture (one hour per week for four weeks) and parallel workshops (1.5 hours per week for eight weeks). The cohort of 130 students was subdivided into four workshop groups timetabled at four different times of the day. The lecturer and workshop leader for all workshops was one of the researchers (IG).

The Design and Technology Course unit

The major considerations impacting on the planning of the teaching and learning experiences for the design and technology course unit were the backgrounds of the students and the fact that the majority of them had undertaken little or no formal study in technology and the technology process in their schooling and undergraduate education. Therefore, the first three weeks of lectures and workshops were planned as a teaching and learning platform for design and technology and consequent involvement of the students in an open-ended, ill-structured, independent technology project.

The lectures focused on inviting students to think about key questions related to design and technology and teaching technology in primary school. A final lecture delivered towards the end of the course unit focused on a discussion of knowledge and understanding associated with innovation and engineering design.

Concurrently, teaching and learning experiences were provided in the workshops that enabled students to immerse themselves into the content and design processes of technology. Activities and tasks ranged from highly structured to less structured ones during the first three workshops. The sequence of activities is shown in Table 1. The students worked in groups of three in this initial phase of the design and technology course unit. The groups were encouraged to mingle and share ideas, information and understandings during the workshops.

In the second phase of the course unit, the students, continuing to work in the same small groups, were asked to select and conduct an ill-structured, independent design and technology project that might be suggested typically by an upper primary school child. The project was conducted over a period of five weeks and involved students in designing, making and appraising a product. No specific guidelines for the production of the artefact were provided, however, sample projects sourced from technology curriculum materials such as The Nuffield Foundation (1998) were available for perusal. If required, the students were given guidance as required in the selection of a suitable task, and issues relating to the whole process were clarified without compromising the independent nature of the project. As a culminating activity, each group of three presented orally an appraisal of their artefact to the whole workshop group in an attempt to foster constructive debate, discussion and critical analysis of each other's work. Again, the groups were encouraged to mingle and share ideas, information and understandings while working on the ill-structured, independent project. Overall, the teaching and learning approaches and strategies adopted were planned to model those any primary school teacher might use in his or her own classroom.

Table 1 presents, in summary form, an analysis of the design and technology course unit for features that could be construed as being representative of an authentic learning environment. Judgements were made based on the criteria of Roth (1998).

Table 1

Features of the Authentic Learning Environment in the Design and Technology Course Unit Compared with the Five Conditions Proposed by Roth (1998).

Criterion:	Features of the course unit
• Problems are either ill-defined or defined so loosely that students can impose their own problem frames.	• Ill-structured, independent project.
· Students experience a sufficient level of uncertainty and ambiguity in finding solutions.	• Highly structured to less structured activities:- designing an artefact to carry a load; strengthening an object constructed of four pop sticks; designing and constructing a bridge. • Ill-structured, independent project.

• The curriculum is predicated on, and learning driven by, students' current state of knowledge.	• Prior knowledge. • *Highly structured to less structured activities:- designing an artefact to carry a load; testing the strengths of materials; discussion and analysis of information about tools, machines, systems; constructing a *Breathing System* (Australian Academy of Science, 1994); strengthening an object constructed of four pop sticks; designing and constructing a bridge. • Ill-structured, independent project.
• Students experience themselves as part of a community in which specific practices and resources are shared and scientific and technical knowledge is socially constructed.	• Working in groups of three; working in workshop groups; involvement in focused appraisal sessions.
• Students can draw on the expertise of more knowledgeable others, whether they are peers, teachers, or outside experts.	• Working in groups of three; working in workshop groups; involvement in focused appraisal sessions; expertise of workshop leader.

* Highly Structured to Less Structured Activities during first three workshops

An assignment in the form of a journal was used for assessing student performance in the course unit. Each student had to include an analysis of workshop activities; original and modified sketches; analysis of the construction of any artefacts; self and peer appraisement of artefacts, in his or her journal. The journal also contained each student's reflections on his or her learning, the technology processes experienced, critical incidents, critiques of design plans and sketches, project notes, and comments about the teaching and learning issues embodied in the course implementation strategies.

Data sources

Prior to the commencement of the design and technology course, all students in the cohort completed a PATT (Pupils' Attitudes Towards Technology) technology survey, comprised of three instruments, designed to elicit and describe each respondent's perceptions of design and technology (Rennie & Jarvis, 1994). The results used in this paper were drawn from responses to the writing/drawing activity that required a written and/or drawn response to the general questions "When you read the word 'technology' what comes into your mind?" and "What does technology involve?"

Semi-structured interviews were conducted with a preliminary sample of 21 students to probe further their responses to the technology survey and to provide additional elaboration of their knowledge of design and technology. The students were representative of a range of understandings of design and technology evident in the writing/drawing activity. In addition, the students were asked to make predictions about, and describe, the experiences they might have during the design and technology course. The transcripts of interviews were returned to the interviewees for member checking (Guba & Lincoln, 1989). The interviewees were invited to provide additional comments for clarification and elaboration if they wished to do so.

Following the process developed by Shapiro (1996), a Repertory Grid was developed reflecting the views of the interviewed group about technology design processes. The survey and initial interview responses were coded and categorised into firstly, a set of Elements (nine) of the technology process, or descriptions of typical situations the students believed they might experience in the conduct of the various workshop activities and tasks of the technology course unit. The set of elements is listed as follows: 1. Selection of a problem for investigation by the participant; 2. Identifying and exploring factors which may affect the outcome of the project; 3. Decisions about materials and equipment may be needed; 4. Drawing of plans may be involved; 5. Building models and testing them may be required; 6. Modification of original plans may be required; 7. Modification of original models may be required; 8. Appraisal of the process and product may be required; and 9. Solving of problems may be needed.

Secondly, the survey and initial interview responses were coded and categorised into a set of bipolar Constructs (ten) consisting of terms and phrases students believed they might use during the various workshop activities and tasks. The majority of terms and phrases were descriptive of the learning environment. The Repertory Grid developed consisted of a seven point rating scale situated between pole positions on the individual constructs, one set of constructs for each element. One Repertory Grid chart for Rose, a case study, is shown as an exemplar in Table 2. Changes referred to in subsequent discussions will be coded as follows: [E2: C(f)5 - 2] refers to a pre-post change of 5 to 2 for the construct *Doing real technology - Doing things unrelated to technology* within element 2 (see Table 2).

Table 2

Sample Repertory Grid Chart for Rose as an Exemplar

The following statement is a brief description of a typical experience you, as a participant, might have whil design and technology project.

ELEMENT #2: Identifying and exploring factors that may affect the outcome of the project.

Rate this experience on the scale of 1 to 7 below for the following constructs, or terms and phrases, you m describing the steps in conducting a design and technology project. CIRCLE YOUR RESPONSE.

CONSTRUCT 1 2 3 4 5 6 7 CONSTRUCT

a.	Creating my own ideas	N	a.	Just following directions
b.	Challenging, problematic, troublesome	X O	b.	Easy, simple

c.	Have some idea beforehand about the result	N	c.	Have no idea what will result
d.	Using the imagination or spontaneous ideas	X O	d.	Recipe-like prescriptive work
e.	A frustrating experience	X O	e.	A satisfying experience
f.	Doing real technology	X O	f.	Doing things unrelated to technology
g.	Theoretical considerations	X O	g.	Practical considerations
h.	Using a specific method to solve the problem	X O	h.	Not using any particular method
i.	Process oriented	X O	i.	Product oriented
j.	Group based/collaborative discussion	N	j.	Individually based

O - placement at beginning of course unit; X - placement at end of course unit; N - no change

The Repertory Grid was administered to the preliminary sample of twenty-one students who rated each of the constructs pertaining to the first element, *Selection of a problem for investigation by the participant*, and then the same constructs for the second element and so on.

Twelve focus students, working together in four separate focus groups, one focus group per workshop, were purposefully selected (Guba & Lincoln, 1989) from the sample of twenty-one for in-depth study during the design and technology course unit. The focus students represented a range of views of technology and technology education as evidenced in their respective responses to the technology survey and follow-up interview. The actions of the focus groups as they worked through the initial teaching and learning experiences and conducted the ill-structured, independent technology project were videotaped, and radio microphones used to capture the discourse within and between the groups. At the same time, field notes were compiled by the research team, which observed closely each of the focus groups. The students' journals of their reflections on their progress, the technology process they were experiencing, critical incidents, sketches, project notes, and comments about teaching and learning issues represented an additional data source..

The research team discussed and developed tentative assertions on the effect of the learning experiences and learning environment established during the technology course unit on the students' perceptions and actions, for ongoing testing as the study proceeded.

At the finish of the design and technology course unit the sample of twenty-one students again completed the Repertory grid. The grids were analysed to identify changes in perceptions on each construct for each element. A second semi-structured interview was conducted with each of the twenty-one students to probe for changes in their understandings of design and technology concepts. As part of the interview, students were asked to review and provide comment on the tentative assertions and any critical incidents that may have altered their understandings of innovation and engineering design.

During the analysis of the data from the second interviews, particular attention was paid to determining if changes in an individual student's views of the learning environment, where applicable, could be linked with his or her actions and discourse from videotape and audiotape evidence, critical incidents recorded in the students' journals, and/or noted in the researchers' field notes, and from pre-post responses that differed by two or more units on the seven point scales of the constructs within the elements of the Repertory Grid (See Table 2 for an exemplar). This was done in order to provide a richer description of the reasons for any changes noted in students' views of technology and teaching technology in the primary school classroom by relating those changes to particular experiences in the design and technology course unit.

The tentative assertions proposed previously were reviewed in the light of data collected from the final interviews, students' journals and the researchers' field notes. The entire data set and final assertions were analysed further to determine the implications for preservice and inservice teacher education.

Findings

Two case studies (Mary and Rose), selected from the twelve focus group students, are presented for discussion and critical analysis in this section. The selection process was based on the presence or absence of a large number of changes in students' responses by two or more units on the seven point scales of the constructs, within the various elements of the Repertory Grid. There are ninety possible changes of this nature overall, on the full set of Repertory Grid charts. Mary indicated one pre-post change of this kind, and Rose indicated twenty-nine pre-post changes of this kind, as a result of engagement in the design and technology course unit. The contrasting cases were chosen to determine if there was a link between changes in views of the learning environment and the depth of acquired understandings about design and technology, and the teaching of technology in primary school.

Case Study: Mary

Mary responded to the writing/drawing instrument in the technology survey by stating briefly that "Technology means computer, television, video, and spaceships." Her view of technology could be described as limited, her response focusing solely on artefacts with no reference to design processes as being an integral component of technology.

The findings from the first interview suggested that Mary's views covered a number of ideas but these did not include comprehensive and linked ideas about design processes. She provided the following response to the introductory question "What does the word technology mean to you?"

> To me it means a lot of things. I sort of think about computers. The other day I was watching something on TV and it was to do with this probe that they used on this gentleman's brain to kill Parkinson's disease, so to me it means a lot of things. It's not just one thing in specific.

Mary elaborated further when responding to additional questions along the same theme.

> Technology is basically, to me, in everything. I mean, just right from the beginning of time you can see how technology has built on in different areas.

> I mean, even in plant life they use different types of technology to produce new breeds and things like that. So, I think, to me it's a very wide thing.

In addition, Mary indicated that technological advancement was initiated by ideas and that the outcome of technological activity was products.

> It [technology] probably starts off with an idea and probably it could be one person's idea and then by working with it, they work with other people. Technology to me always produces something, so now whether that can be more defined information on something or whether it produces a building or a vaccine or whatever, I don't know.

Mary was unable to predict and describe to any significant extent the experiences she might have as a student participating in a design and technology course unit. She suggested that the course unit would entail involvement with computers in some way but could suggest little more concerning the content of such sessions. She imagined "There would be a lot of, you know, hands-on work. You'd be actually physically doing something as well as probably writing down from the board or given notes on particular technology." She was able to say more about teaching strategies and the possible learning environment by suggesting that group interaction would have to occur and guided, hands-on activities would be a prominent feature of the learning environment.

Mary's views of technology education appeared to be dominated by her own prior experiences in primary and secondary school and a field experience session in the first semester of her preservice teacher education course. She believed that, as a teacher in the classroom, she would need to find out the children's base knowledge of the particular technology topic in order to organise the rest of her planning. Her implementation of the program would be as follows:

> Well they have got to have an activity to do and have, you know, a format to follow, maybe some steps to go through and use the equipment and then record their results. Some sort of outcomes, something at the end.

All Mary's initial responses to the Repertory Grid were placed on the points 3, 4, or 5 on the seven point scale for each of the constructs within each of the elements, thus suggesting uncertainty about the learning environment she was about to encounter.

In the first phase of the technology course unit, Mary appeared to be the least active member of her focus group (Mary, Angela and Ivor) in terms of collection of materials and tools needed for constructing the artefacts and carrying out testing procedures. However, she did make important contributions to the many discussions that took place by providing insights into the properties of materials and assisting in the establishment of design criteria for constructing the artefacts such as *A Breathing System* and the bridge. Some of Mary's early journal reflections convey already her sense of the value of belonging to a community. For example:

> As a group we all shared in the discussion about technology. Everyone did listen to what each person had to say and also made additional comments. ... I did enjoy making the *Breathing System* and our group did work well together as a team. ... It was interesting to see the different designs used to make a bridge as we walked around the room.

In the second phase of the course unit, Mary's focus group decided to construct a boat for their ill-structured, independent project. Extensive discussions were held about its proposed structure, size, and shape and about how it was to be powered. An agreement was reached that the boat would be a hollow hulled boat shaped from balsa wood, powered by a "jet" engine: a pump from a car windscreen wiper motor brought in by Ivor. Video recordings and field notes compiled during the workshops revealed that discussion was extensive throughout the project as particular problems arose or as decisions had to be made. For example, the pump stimulated at least 45 minutes discussion about its workings, how it was going to be incorporated into the structure of the boat and what structural changes would have to be made in order to house it. Diagrams, drawn mainly by Angela, were used by the group as support, illustration and a focus for the group's developing ideas. Although Mary contributed less verbally to these discussions than Angela and Ivor, she did identify the worth and role of the drawings for establishing a problem frame.

> For me, I was learning by listening and looking at the drawings that Angela had drawn (while drawing these sketches she was also giving an explanation to her idea). I believe this process is an important step in the brainstorming stage and is very helpful to people who don't know very much about the topic.

Mary tended to take a more passive role as listener, making occasional important interjections, compared to Angela who appeared to assume a leadership role by facilitating as well as contributing extensively to the development of ideas and to the progress towards the group's construction of its boat. There were many complex negotiations and sharing of ideas between Angela and Ivor accompanied by their active engagement in the hands-on construction of the boat.

Problems emerged as Mary's focus group manipulated materials and attempted construction of the artefact. They found that they were not able to foresee or predict the problems until they faced them, thus the learning experience presented them with uncertainty and ambiguity in finding solutions (Roth, 1998). For example, initially, gluing was the only means considered for joining the wooden parts of the boat. When the practicalities of gluing had to be faced, it was decided that because of the fragility of the wood which had to be bent to shape, nailing and then stapling were also needed, both in conjunction with glue, to provide a firmer join, thus improving the structural strength. The group also had to deal with the difficulties of bending the balsa wood to form the curved sides of the hull, the practicalities of which were not considered at all during the initial planning of the ill-structured, independent project.

The continual problem solving, and indeed the variety of types, or levels of problems, similar to those that arose during this group's design task have already been recognised elsewhere (Roth, 1995; McCormick, Murphy, Hennessy, & Davidson, 1996). The solutions to such problems are a product of the complex interplay amongst a variety of variables, including materials and tools at hand, interactions with colleagues, as well as purposes or intentions of the tasks and subtasks (Roth, 1998). Mary observed elements of this complexity in her journal by noting that problems do not end once planning has finished.

> There was still a lot of discussion, testing and evaluating happening in this phase [making phase] as well. I enjoyed this phase, as it was fun to build something from our designs and actually see it take shape. There was a lot of problem solving happening in this phase. This was to do with the construction and the best way to mould the balsa wood into its new shape and how to fix both pieces together.

While her contributions to group discussions were limited, she did make suggestions when she could and asked questions of the other two group members to clarify her understandings. She was confident and comfortable with the part she played expressing the view, in both her journal and second interview that she believed she was accepted as a important member of the community.

> From my point of view I found the exchange between the two of them [Ivor and Angela] helped me understand the concept of what Ivor was planning [referring to his ideas about the water pump], even though I did not participate in the discussion very often. (Journal)

> There was no animosity or anything like that that happened in the group. They'd say to me, 'Oh [Mary], what do you think about that?' And they were trying to draw me into the conversation as well, even though they were the more dominant people, they were still trying to include me, which was a really good thing to see. (Interview)

Mary lacked confidence in her overall knowledge about technology, technology education and more specifically about the building of model boats at the beginning of the course unit. Changes in Mary's second Repertory Grid responses were minimal, but pointed. For eight elements, construct *(e) A frustrating experience - A satisfying experience* changed from 4 to either 5, and in the case of Element 1 (Selection of a problem for investigation by the participant) 4 to 6, that is, towards *A satisfying experience*. This set of responses represents evidence to support the personal satisfaction Mary expressed in her journal comments about her experiences of the technology course unit overall.

At the conclusion of the course unit, Mary believed that her greatest development had occurred in terms of her becoming much more clear about what could be involved in design and technology projects. Mary's comments also illustrate her sense of the importance of community and the need for problem solving as part of the learning environment.

> I believe I have a clearer understanding about technology from this process of working in a group. My understanding is that whether I'm teaching or learning about technology it's all about discovery and sharing of ideas with other group members or with other groups in the class. It's about getting students to question and identifying problems, or solutions to problems that may arise. It calls on you to make predictions, classify materials, problem solve, work in small groups, hands on activities, design, make and appraise constantly through all areas of development. (Journal).

Her personal confidence about tackling an ill-structured, independent project herself was increased and as a consequence she felt more able to implement one in her own future classroom. This was the result of her positive reaction towards the approach taken during the course.

> I think the actual process of going through and reflecting upon your group work and what was happening with your technology and your artefact that you were making, has sort of been very beneficial. I really think that there's nothing better than sort of getting in there and having a go, but looking at it from both points of view as well, not just from the making of something, but also reflecting upon what was happening within the group, and looking at how we all attack different situations.

Mary now understood that, whether she was teaching or learning about technology it's all about discovery and sharing of ideas with other group members, or with other groups, in the class. For her classroom it would be getting children to ask questions and identify problems or solutions to problems that may arise in group situations.

Case Study: Rose

Rose's response to the writing/drawing instrument in the technology survey focused on the societal implications of technology, for example, the rapid changes caused by technological innovation have important implications for the work and leisure activities of people.

> Technology means to me the language for rapid change that our society is experiencing at an ever-increasing rate. The introduction of computers has been one of the greatest leaps forward for civilisation since the industrial revolution. Technology has altered how we live, think, work and play. It is continually metamorphosing itself to achieve greater outcomes for society especially in the areas of medicine and food production.

The findings from the first interview with Rose indicated that her views of technology, like Mary's, included a number of ideas but they were not comprehensive. She saw technology in a scientific way as "An applied science or something to do with engineering, or thinking different theories." She elaborated further by stating that "It's a progression of technologies, it's something that's applied, particularly in the industrial world, so it's come before computers."

Technological advancement and the production of artefacts, in Rose's view, were the result of activity where:

> They start with a concept and develop it from there into something that is constructed that can be applied. That's why I think of it as an applied science. (They draw on) the knowledge they have, or the knowledge that they may be testing, and then develop it into a useable form by using whatever materials are available at that particular time.

Rose continued by suggesting that the activity of developing a concept, or an idea, into a useable form may involve a lot of trial and error and some ideas may not be feasible because the relevant knowledge base for developing them further is inadequate.

Rose's initial reaction to the thought that she would be involved in an ill-structured, independent technology project, was that it would involve the use of computers and the latest computer technology. When advised that it may not involve the use of computers at all, but may involve an activity such as building a model boat, she replied:

> Well, I'd probably consider first of all the materials that I would use. I mean something that was going to float, and the design of it and what features I needed to incorporate in the design of it to make sure that it floated.

The terms and phrases Rose believed she might use in the construction of the boat were associated with "What are we going to use to make the boat with, how should we go about developing a design concept and, possibly, some explanations of terms (such as) float action (buoyancy)."

Rose, like Mary, was unable to provide detailed descriptions of the experiences she might have as a student participating in a design and technology course unit. Rose could not articulate comprehensive and linked ideas about the design processes of technology. She did believe, however, that group work and brainstorming ideas would be a prominent feature of the learning environment.

Rose espoused a problem solving approach, based on group work, as her preferred method of teaching design and technology in her own classroom. Tool use would be an important component of the approach.

> I'd have them in groups scattered around the classroom, depending on the (classroom) environment, but they'll be in small groups with different problems to address using different concepts, or maybe using the same concept but different outcomes. Then that could be something where they could rotate with and so maybe develop the skills to a wider application.

The majority of Rose's initial responses to the Repertory Grid were placed on the points 3, 4, or 5 on the seven point scale for each of the constructs within each of the elements. These responses, like those of Mary's, suggested some uncertainty about the learning environment Rose was about to participate in. Rose initially responded by marking point 2 on the construct *(j) Group based, collaborative discussion - Individually based* for each of the nine elements which reflected her belief that group work would be a prominent feature of the learning environment. Her responses on five of the elements for the construct *(g) Theoretical considerations - Practical considerations*were placed on point 6 which is consistent with Rose's view of technology as being an applied science or something to do with engineering. Therefore the technology course unit was likely to have a highly practical orientation.

In the first phase of the technology course unit, Rose's focus group (Rose, Kate and Maree) grappled enthusiastically with the various problems presented. After completing the activity *Testing the strength of materials,* Rose acknowledged in her journal that her knowledge about which materials were the most suitable to meet particular criteria was limited and that she would need to do some research to find out answers. She remarked that a teacher introducing design and technology to a class for the first time might resort initially to a structured activity such as *A Breathing System* in order to immerse them in the design processes that need to be considered when constructing an artefact. The teacher would need to provide scaffolding in the form of open-ended questions to promote higher level thinking about design and design problems. Rose's journal reflection "The examination of other groups' bridges, and the sharing of ideas, is an important part of the learning process" conveyed her sense of the importance of being part of a community of knowledge builders.

Rose's focus group decided to construct a pet feeder for their ill-structured, independent project. The ensuing discussion raised a number of questions that needed resolution for example, should it be "A dry food feeder that either a cat or a dog could work out how to use," and should it be "...independently standing or attached to something like a cupboard door." The advantages and disadvantages of the various options were examined without a firm decision being made at that time. The discussion was accompanied by the drawing of sketches, and modification of the sketches as the advantages and disadvantages were evaluated. Criteria for the selection of materials needed to construct the pet feeder were also established. The feeder had to be constructed of weatherproof, durable materials that would prevent the entry of small animals such as ants. The issue of how the dog would access the food was the course unit of some debate. Rose suggested a possible solution to the problem at the same time as modifying their sketches.

> Why don't we just have a sort of pulley system, when you press that down (one side), it (the other side) lifts up. It releases like a pulley lever system.

Subsequent testing of a pulley mechanism for dispensing food from a bucket hopper proved to be a critical incident for the focus group. The uncertainty and ambiguity of finding solutions to an ill-defined problem was reflected in a comment Rose recorded in her journal:

> We realised our pulley system design concept was not going to be feasible. Already we were discovering the importance of the design phase. Through this appraisal process we were able to come up with a less complex design.

Rose concentrated on refining her drawings, posing relevant questions, and proposing alternative designs for the component parts, while Maree and Kate conducted most of the hands-on aspect of the construction of the feeder and testing of component parts. Rose also sought additional information from print resources and other students in order to resolve design problems. Maree and Kate appeared to be more willing to compromise and overlook some of the design criteria they had established originally as a group, in order to complete the task. Rose, in contrast, was more persistent appearing to personify the thoughts she expressed in her reflective journal.

> These artefacts are the products of mental processes that use creativity to produce innovation, logical thought to enhance problem-solving skills, and flexibility to adapt to changing circumstances. (Journal)

The delivery of a fixed quantity of dog food by activation of a lever, outside the feeder, presented another emergent design problem for Rose's group. The mechanism of a lever attached to a piece of dowel that, in turn, was fixed to a round ice cream lid as a trapdoor inside the feeder, worked irregularly when tested a number of times. The weight of the food sitting on the trapdoor appeared to be the source of the problem. The 'failure' of the lever mechanism to deliver food satisfactorily appeared to be a further critical incident for Rose. Alternative designs were drawn and discussed but no attempt was made to construct a modified feeder, although it was evident that Rose was willing to persist in attempting to solve the problem.

At the end of the ill-structured, independent project, Rose suggested that a lack of personal knowledge of materials had hindered the construction of the pet feeder. On reflection, she believed that her group should have investigated the properties of the materials they were planning to use for the feeder prior to commencing construction. Determining the properties of the materials would have broadened her knowledge base and assisted in producing a better design for the artefact. She summarised these ideas by suggesting that "There are a variety of properties that must be considered when choosing materials for a specific purpose." Rose considered that her prior perceptions of technology had been challenged.

> It was a great learning curve in terms of how to go about (a project). The steps that are taken from coming up with a concept to actually producing a design and I've never thought about it prior to this course. When we first talked about what technology was I could only talk about the end product - what I perceived technology to be. I had not really considered much about the design process that goes into it. (Second interview)

In contrast to Mary, Rose revealed a number of changes in her views of the learning environment through her second set of Repertory Grid responses (See Table 2 for an exemplar). Three examples are discussed as follows. Firstly, her views of the ill-defined nature of the project and the uncertainty and ambiguity of solutions may be observed in changes of two scale units or more towards the challenging, problematic, troublesome pole of the construct *(b) Challenging, problematic, troublesome - Easy, simple* for five elements, or typical experiences, in the design process [E2: C(b) 6 - 2]; [E3: C(b) 5 - 3]; [E4: C(b) 4 - 2]; [E5: C(b) 4 -2]; [E6: C(b) 4 - 2]. Her experiences with, and comments about, the critical incident with the pulley mechanism for the dog feeder is further evidence of a change in Rose's views about the learning environment. Secondly, Rose's awareness that learning is driven by her current state of knowledge is consistent with changes of two units or more towards the theoretical considerations pole of the construct *(g) Theoretical considerations - Practical considerations* for three elements [E1: C(g) 6 - 4]; [E2: C(g) 6 - 4]; [E8: C(g) 6 - 4]. She had already expressed concerns about her knowledge of materials several times in her journal. Thirdly, there were changes of two or more units towards the doing real technology pole of the construct *(f) Doing real technology - Doing things unrelated to technology* for six elements [E1: C(f) 6 - 4];. [E2: C(f) 5 - 2]; [E3: C(f) 5 - 2];. [E4: C(f) 4 - 2]; [E5: C(f) 4 - 2]; [E6: C(f) 6 - 2]. This result is in accord with her deepening understandings of design and technology evident in her journal and the second interview data. It is suggested that the range of changes in her views of the learning environment evident in her Repertory Grid responses may be equated with her in-depth and comprehensive views of design processes acquired as a result of engagement in the design and technology course unit.

Rose attested, in her journal and the second interview, that being presented with a real life technology problem had motivated her and stimulated her thinking about teaching technology in the school classroom and she able to add to her earlier comments by stating:

> If it (the real life problem) was presented in a teaching situation it could provide a real context in which to develop other learning activities across the curriculum. (Journal)

The observations of the learning environment and changes in perceptions of technology as a design process highlighted in the case studies of Mary and Rose were representative of those by their respective focus groups. The students were able to describe clearly the impact of their engagement in the design and technology course unit, including the ill-structured, independent technology project, on their own teaching of design and technology in elementary school classroom. Most recognised the need to evaluate what they were doing in terms of the content and processes of design and technology and relate those learnings to pedagogical issues in the primary school classroom.

Discussion

In the preservice teacher education course unit, opportunities were provided for students to reflect on their own and others' conceptions of technology, on technological practices, and on pedagogical knowledge. The design and technology course unit consisted of features that met the criteria for an authentic learning environment proposed by Roth (1998). The following assertions draw together some important aspects from the in-depth analysis of the two case studies, Mary and Rose.

Assertion 1. Repertory Grids are useful for acquiring insights into preservice teachers' views, and changes in those views, of a technology learning environment.

The developments and changes expressed by Mary and Rose concerning their perceptions of the learning environment were supported generally by evidence from the Repertory Grids. Fine-grained changes were found in Rose's views of the learning environment that could be equated with evidence from interviews, videotaping of classroom activity and her reflective journal. No fine-grained changes in Mary's views of the learning environment were found in her Repertory Grids. However, other evidence suggested that she experienced greater changes than her Repertory Grid actually indicated, hence, it appears that Mary may have been overwhelmed by the complexity of the Repertory Grid. Work should continue on further refinement of the Repertory Grid as it has the potential for capturing the intricacies of participants' ideas, and changes in those ideas, about the learning environment associated with technology processes. Developments should include reducing the apparent complexity of the grid itself, or requiring respondents to complete the Repertory Grid during an interview, so that ideas and indications of changes can be probed immediately.

Assertion 2. An authentic learning environment in a design and technology course unit containing an ill-structured, independent project can make important contributions to the acquisition of deeper understandings of relevant design and technology concepts.

The case study students, Mary and Rose, responded favourably to the authenticity of the ill-structured, independent projects in which they were engaged. The projects were regarded as authentic because they were self-selected, and emerged from problems that the students had identified themselves, and were seen as being real life problems. Both tackled the problems in ways they felt were most appropriate within the limitations of their existing knowledge states, available resources and time. All of the action took place within the framework of technology in primary classrooms, and so throughout, thoughts and comments, ideas and changes were made in relation to teaching and learning, as well as to the final product outcomes.

The authentic nature of the project became the enabling factor for the development of many of the other learnings perceived as important by Mary and Rose, for example, those related to shared, collaborative interactions within, and across groups, and the social construction of design and technological content knowledge. Through these experiences the discourse of design and technology was supported. The discourse of a field of study is integral to it and a vital aspect of learning when becoming a participant within any community (Lave & Wenger, 1991). Likewise, the role language plays in the development of understandings within science/engineering learning communities in schools has also been identified as integral (McGinn, Roth, Boutonne, & Woszczyna, 1995; Roth, 1995; Roth, 1996). The design and technology course unit provided an environment for authentic discourse development to occur. In turn, this aspect of the authenticity enhanced the students' thinking about the technology and the technological processes in which they were engaged. In other words, the authenticity of the learning environment facilitated use of the discourse to support the action and for the action to support the development of the discourse.

Assertion 3. The framing of the technology tasks presented to preservice teachers in an authentic learning environment can provide direction and structure for their learning by highlighting what is important about technology and raising awareness of issues related to the learning and teaching of technology in primary classroom situations.

Mary and Rose, like the majority of the study group, had little formal background knowledge about technology. Hence, the initial workshop sessions during the course unit served to alert them to the nature of design processes and problem solving that they may not have come in contact with previously. This introduction, together with access to teacher resources (Australian Academy of Science, 1994; The Nuffield Foundation, 1998) provided a basis on which all students could formulate their plans and discussions during their initial group work and ill-structured, independent projects. The students were provided with some direction and structure upon which to base and develop their ideas about technology and the practicalities involved in making their artefacts.

Similarly, the interests of the preservice teachers were directed towards teaching and learning in primary situations, therefore, the various tasks were framed around the need to think of a project that could be selected or undertaken by primary students. Throughout the project, this framing of the task supported not only the students' interest in teaching and learning, but also represented and highlighted for them what their actions and decisions could mean in the light of learning and teaching within primary school settings.

The formal appraisement episode that took place towards the end of the course unit served to reinforce the connections of the students' experiences with primary classrooms as the students questioned and reviewed each others' work with these ends in mind. Issues found relevant by the students were raised and discussed. These issues related to such things as the availability of resources; the practicality of the tasks; the difficulty of concepts underpinning the workings of artefacts; the time involved for designing, making and appraising; the strategies to use to stimulate thinking and reflection on ideas and outcomes; and the educational value of technology. In this way, the relevance of the ill-structured, independent projects was emphasised, not only in terms of the students' own learning about technology, but also in terms of what technology education in primary classroom settings could entail. Some implications of this study are discussed in the next section.

Implications

First, the Repertory Grids provided insights into Mary and Rose's perceptions of design and technology learning environments even if there were only small (Mary), or no changes resulting from engagement in a technology course unit. Repertory Grids have the potential to provide a fine-grain level of information that other data sources such as reflective journals may not necessarily give. The more detailed information may be of particular use to both learners, as a means to make explicit what they do know and also as a focus for reflection upon technological processes, and course designers - as a means to help plan for learners' needs and understandings.

Second, learning experiences that engaged Mary and Rose first-hand in ill-structured, independent projects broadened and deepened their understandings about technological processes. The projects provided opportunities for authentic and personal experiences that, enabled students to express more comprehensive views of the complexities of engaging in design, for example, the recursive nature of designing, making and appraising, and to become conscious of the interdependence of technological processes, materials, information and systems. In addition, these types of projects highlight the role that language plays in the development of technological understandings and its importance for legitimate participation within technological contexts and communities of knowledge builders. For many students, such experiences raised to conscious awareness knowledge and ideas that they believed they had already experienced in the past, but which they had taken for granted.

A third implication relates to the development of knowledge about technology education in primary classroom settings. Strategies adopted for creating an authentic learning environment, during a technology course unit increased Mary and Rose's awareness of ways for teaching technology in the classroom. From the outset, learning experiences that ranged from highly structured to less structured activities, helped preservice teacher education students to engage in personal learning about technology, as well as to reflect upon implications for primary teaching. Exposure to what might be called the "content" of technology education, such as materials, information, systems, was important as many students expressed a limited understanding of what constitutes the key learning area, technology. Helping students gain insights into the ways that the selection and nature of materials, for example, impinged on the designing and making of technological artefacts early in the course, and then asking them to consider the place of materials in design projects and how to help children understand materials was a way of introducing them to this "content." Such activities provide a platform upon which the students can then draw ideas for later decision making within their own open and ill-defined projects. Using these types of approaches in course units, preservice teachers can be encouraged to review and reflect continually upon their actions and ideas in terms of appropriateness and applicability to primary classrooms. As a consequence, awareness of classroom implications can be raised and opportunities created for explicit discussion of issues.

Conclusion

The study thus confirms the value of establishing authentic learning environments in technology course units for preservice primary teachers as a way of changing their perceptions of technology and technology education. The ill-defined nature of problems and the uncertainty and ambiguity in finding solutions to the problems in the technology course unit provided a rich learning environment from which the preservice teachers were able to draw implications for their future primary classroom situations. The nature of the activities and tasks in which they were involved stimulated their reflections upon themselves as learners, upon their learnings about technology and technology education. They were able to comment upon their experiences and link them with their prior knowledge and changes in their thinking about technology and technology education. This personal and practical involvement meant that the nature of technology and technological activity was also represented within, and as part, of the action. An important feature of the action was the opportunity for students to share resources and practices and be part of knowledge building community. In addition, issues related to technology education were either experienced or raised upon reflection on experiences. In this study the preservice teachers *themselves* recognised the value of their participation in structured, less structured and ill-structured, independent technology projects. Not only was their awareness of technology, its nature, and design processes raised, but also insights into their own learning experiences were gained.

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