Design and Technology for pre-service primary teachers

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In many education systems in the western world, Design and Technology is now an important part of the school curriculum. In Queensland, Australia, Technology is one of the *Key Learning Areas* (KLA's) for students in compulsory years of schooling. The Technology Syllabus was completed and trialled in Queensland primary schools in 2003. The syllabus encourages students to think creatively and work technologically. This paper describes how design and technology was taught to pre-service primary teachers at an Australian University. The pre-service teachers were involved in a range of activities which promoted creative thinking, active learner involvement, team work, problem solving, working technologically, and engagement in authentic tasks. The tasks included designing and making products such as kites, land yachts, towers, bridges, and LEGO robots. Activity sequences, based on the products made, are planned by the pre-service teachers and involve the phases of the Technology Practice Cycle identified in the Technology Syllabus. Teams of pre-service teachers also used the cycle of Investigate, Ideate, Produce, and Evaluate, to create their own technology products. The use of Wikis, Blogs, and digital videos are integral to sharing ideas within the teams of pre-service teachers and across the unit cohort. The paper also provides examples of pre-service teacher feedback on various aspects of the Design and Technology unit.

Introduction

Design and technology have played a significant part in the "evolution" of the human race. The ability of humans to conceive ideas and transform them into reality has been an important part of the evolution process. The economic prosperity of many nations depends upon its citizens to innovate and deliver products to fulfil human needs and wants. Yet within the schooling system in Australia, design and technology has not been a priority area until recently. In primary schools, technology was embedded in the science subject while in high schools it was taught as an optional specialist subject; such as woodwork, metalwork and home economics. It appears that technology education has "struggled to establish itself as an equal partner in general education and often struggled to gain recognition for the value of its instruction" (De Miranda, 2004, p. 61).

In countries such as the U.S. and England, Design and Technology has been a part of the school curriculum for sometime. However, it is believed that the content covered by K-12 technology, innovation, design, and engineering (TIDE) educators in the U.S. was not sufficient to advance the innovation agenda (Starkweather, 2005). According to Starkweather "the mentality of educational systems in the majority of countries overlooks the attributes of a TIDE education, does not include the big picture of

innovation, is shortsighted, or does not exist at all"(p. 29). Starkweather also believed that the importance of TIDE subjects to demonstrate innovation and invention outcomes had diminished because teachers have not "always been taught to explore the virtues of innovation as part of the curriculum" (p. 29).

In England on the other hand, it was reported that there were fewer examples of good teaching in design and technology than in other subjects (HMI, 2004). A beginning teacher's experience in a design and technology classroom in a Queensland (Australia) school revealed that her limited knowledge of the topic and the syllabus impacted on her ability to conceptualise and implement appropriate learning experiences (Stein, Ginns & McRobbie, 2003). Findings such as these suggest that pre-service teaching courses should enable students to embrace innovation and inventions ideas in order to enable them to create productive learning environments in their classrooms. They should also have an understanding of the concepts and confidence to implement learning activities once they qualify as teachers.

Design and technology in Queensland

In Queensland (one of the six states in Australia), the curriculum in the first ten years of schooling is divided into eight *Key Learning Areas* (KLA's). Technology is one of the KLA's. This syllabus was first introduced in 2003 and it became compulsory in all schools in 2007. The syllabus describes technology as follows:

> *Technology involves envisioning and developing products to meet human needs and wants, capitalise on opportunities and extend human capabilities. Products of technology include artefacts, processes, systems, services and environments. These products make up the designed world. Products of technology have impacts and consequences on individuals, local and global communities, and environments.*
> (Queensland Studies Authority, 2003, p. 1)

The syllabus emphasises the idea of working technologically which is achieved by applying the four learning outcomes embedded across four strands – Technology Practice, Materials, Information, and Systems. The Technology Practice Cycle forms an important part of the Technology Practice Strand. When creating a product, it emphasises the importance of the four critical inter-related phases - Investigation, Ideation, Production and Evaluation. The syllabus also highlights the importance of appropriateness, context, and management in relation to product development (Figure 1).

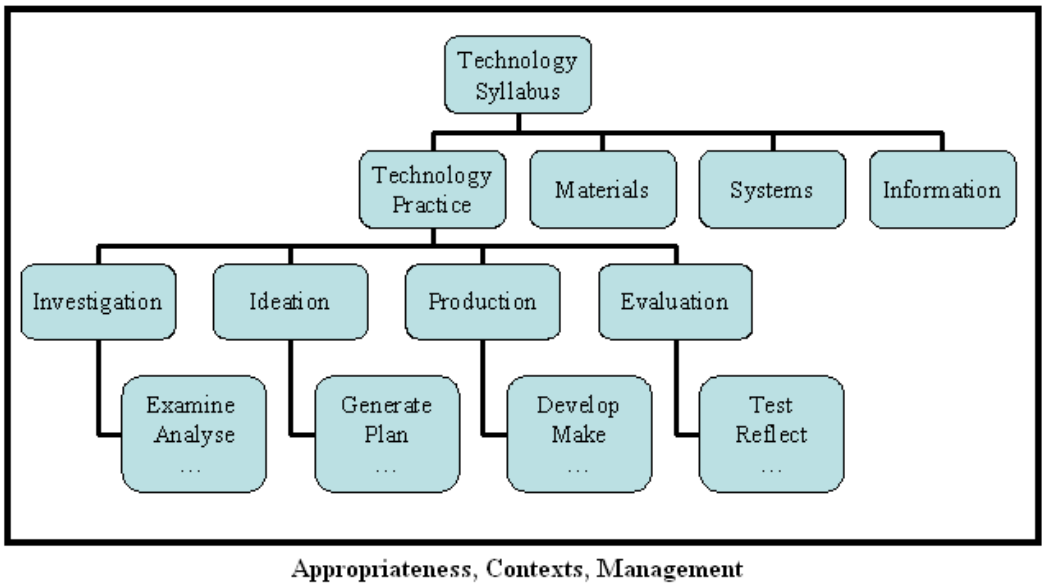

Figure 1. Layout of the Queensland Technology Syllabus

Design and Technology for pre-service teachers

The unit in this investigation gave the pre-service teachers an opportunity to examine teaching and learning issues inherent in the four strands of the Technology KLA. This included content and pedagogical issues associated with design and technology education. Assessment and workshop tasks were aimed at promoting teamwork and in the process developing a thorough understanding of the Technology Practice Cycle and how it fitted in with the rest of the syllabus. Collectively these approaches promoted attributes of life long learning such as: developing a deep understanding of the concepts, actively investigating, effectively reflectively and communicating their results (Queensland Studies Authority, 2003).

Project-based learning was a significant part of student assessment within the unit. Such an approach enables students to engage students in a sustained and cooperative investigation (Bransford & Stein, 1993). This approach "takes the focus off the teacher imparting knowledge to the students and places it onto students working together to actively construct meaning." (Cole, 2003, p. 16) It is well aligned with a constructivist approach where students are "active agents in a learning process characterised by recurrent cycles of analysis and synthesis, action and reflection" (Mioduser & Betzer, 2007, p. 61). Significantly, students engage in real life "hands-on" activities, solve realistic problems, and understand limitations of what is doable before the final product is produced.

The Project-based learning approach adopted in this instance enabled students to engage in a recursive cycle of Investigation, Ideation, Production and Evaluation – all of which are essential phases of the Technology Practice Cycle. In doing so they engaged in the strands of the Technology syllabus – Information, Materials, and

Systems. One significant aspect of this task was that the project involved teams of students creating a product of their own choice. Tutors helped students to refine their product choices if there was a need.

Method

The Queensland Technology Syllabus was an important part of the teacher training unit. Lectures, workshops, and assessment tasks were geared towards giving the students an understanding of design and technology concepts and the skills needed to unpack and implement the syllabus document in their future classrooms.

The first assessment was based entirely on the workshop activities. Kites, containers, marble machines, bridges, towers, Lego robots, and land yachts were some of the products created in the workshops. Images of products created by students in these workshops were used to produce a multimedia presentation (using *Microsoft Photostory 3 for Windows*) each week. These multimedia slideshows were shown at the beginning of the tutorials and were made available on the unit's *Blackboard* site.

These workshop activities highlighted the significance of a learner-centred approach which is considered to be an important element of the Technology syllabus (Queensland Studies Authority, 2003, p. 1). As part of the assessment, students used these activities to develop a design and technology portfolio which consisted of a number of technology lessons. Each lesson had to clearly state the learning outcomes, design challenge, materials list, and activity sequence.

The second assessment took a project-based learning approach and was an extension of the first assignment (Figure 2). They had to work in groups and construct a product using their own designs. More importantly this product was something that they would expect their students to produce in the future. Consequently they also had to backwards plan a curriculum proposal associated with their task. The choice of appropriate learning outcomes and an analysis of their learning were integral parts of this activity.

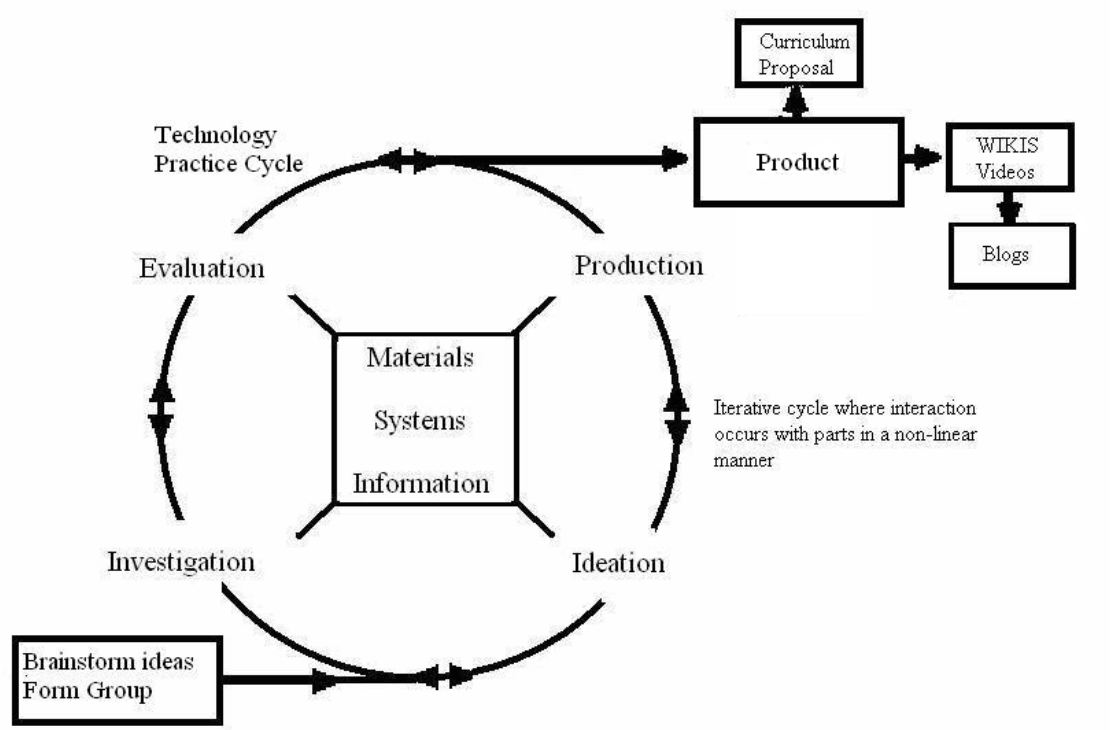

Figure 2. Project-based learning model

The pre-service teachers formed groups with three to four members to complete their own technology products which were presented in class during the last week of the teaching semester. The groups had four weeks to decide on an idea and then design and construct their product. During their product construction the groups were engaged in the Technology Practice Cycle and other strands of the syllabus. An iterative cycle formed the basis of product construction where interactions occurred in a non-linear manner. Students would for instance, engage in the ideation phase of the development by taking into consideration aspects of the Materials strand of the syllabus. They would then investigate and evaluate the materials before moving to the production phase of the Technology Practice Cycle.

As part of this assessment the pre-service teachers were required to submit a classroom activity based on their product. They also had to complete a WIKI in which they reflected on their engagement with the Technology Practice cycle and other strands of the syllabus. They also had to reflect on six critical stages of product development in their WIKIS. An online group space with a range of tools such as email was provided for the groups as a collaboration tool for their assessment. The use of the group space was not compulsory. The group space included a blog, a chat room, and a file exchange system. Digital videos were taken of each group's final product presentation and added to the *Blackboard* site so all the pre-service teachers enrolled in the unit could access ideas of other groups in the cohort. Students used the digital videos and the WIKIS to comment on another group's presentation through a Blog which was specifically setup for this purpose.

Participants

The participants in this course consisted of two hundred and fifty third year pre-service primary teachers. This Design and Technology unit ran for ten weeks. The pre-service teachers complete the compulsory unit as part of their four year Bachelor of Education (primary) degree program.

Data collection

A descriptive case study was used for data collection and incorporated a questionnaire and a survey. A case study method was used in order to ascertain the viewpoint of the pre-service teachers enrolled in the unit.

A qualitative method was also used for data analysis, mainly because the focus of the study was concerned with the pre-service teachers' perceptions of the learning activities and resources used in the unit. Data was collected in week four and week eight of the semester.

Week 4 Data

The data from week four consisted of answers to a questionnaire based on questions used in the Queensland Technology Syllabus Initial In-service Materials booklet (2003). Thirty one pre-service teachers from two tutorial groups where asked to individually complete the questionnaire.

After completing the Bridge and Tower activity in week 4 the pre-service teachers were asked to individually answer a series of questions. These questions were administered to establish students understanding of this task. Students answered the following questions:

- What was the first thing that members of your group did after reading the activity?
- Do you consider this to be a closed or open task?
- What did you notice about participation as the activity progressed?
- During the activity, did the group backtrack, start again, stop and review how the task was progressing?
- Did some testing take place when options were being considered?
- In considering ways in which the activity was undertaken, is it possible to specify occasions when investigation, ideation, production, and evaluation were taking place and whether these occurred in iterative, cyclic, or recursive ways.
- What strands with Technology Practice were you considering? (Materials, Information, Systems).
- What else could you consider? (Context, management, appropriateness).

Week 8 Data

Data from week eight consisted of responses to a survey which contained a Likert scale ranging from strongly disagree to strongly agree. The survey asked the pre-service teachers to give feedback on the Photo Story presentations, online group spaces, Wikis, and digital videos that were a part of the unit.

One hundred and seventeen pre-service teachers from six tutorial groups completed the questionnaire on the resources. The pre-service teachers were asked to rate each resource using the following criteria:

- The resources are easy to use.
- The resources are useful for the assignment or for future reference.

The pre-service teachers were also asked to comment on the most useful aspects of the resources and how they could be improved.

Data analysis

Data consisted of answers to a questionnaire and a survey. The survey was analysed by comparing the percentage of answers that fell into the different categories stated on the survey regarding how easy the resources were to use. The resources included the weekly slideshow, group space, and WIKI. The questionnaire was used to assess the perceptions of the pre-service teachers regarding one of the learning activities engaged in during the Design and Technology unit.

Results

The data gave insights on the pre-service teachers' perceptions of the learning activities and resources used in the unit.

Week 4 feedback

The results from the questionnaire completed in week four showed that the pre-service teachers were engaging with the Technology Practice Cycle during the Bridge and Tower structure activity. Responses included the following comments:

> *Investigation was mostly done in the beginning where triangle was seen to be strongest shape. Ideation was in form of discussion and drawing. Production was iterative. Evaluation was done during the testing with weights*
>
> *We investigated & designed a tower giving ideas of what would work & what wouldn't. The production was all hands on with evaluation occurring continuously throughout.*

Most of the pre-service teachers (88%) identified the task as an open task and stated that they drew or sketched their ideas on paper before their group constructed their structure. This finding relates to the design aspect of the Technology Syllabus (2003) where the sketching of designs prior to production is an important process.

Evaluation is also an important process in the Technology Practice Cycle and can occur at different stages of the cycle (Queensland Studies Authority, 2003, p. 1). Most pre-service teachers indicated that they either backtracked or reviewed the task as they completed the activity. The majority of the pre-service teachers (77%) also indicated that they tested their construction at different stages of the production. The pre-service teachers stated that they had used their hands to place pressure on the structure or used weight as they were building. Students explained their approaches as follows:

> *Yes -we tested quite a bit which then led to other ideas if they didn't work*

At some stages we added some weight to see if what we had decided to do would work

We kept on putting our hand on the tower's platform to test its stability

However, about one fifth of the sample (19%) indicated that testing only occurred at the end of the activity. The final evaluation involved the pre-service teachers testing their structure by placing 1kg weights on the top. One pre-service teacher commented :

All testing was done at the conclusion of the activity.

The Materials strand of the Technology Syllabus was considered by the pre-service teachers as well as the Technology Practice strand. The pre-service teachers indicated that they also considered aspects of Context, Management, and Appropriateness as they completed the activity. One pre-service teacher listed all three aspects and described how they could be considered when using the activity in a classroom.

Appropriateness -of environment, functions & economic -what community? How big?
Context -where is the bridge for? A walking or transport
Management -timelines, managing of materials health & safety

Week 8 feedback

The results from the survey (see Table 1) completed in week eight were positive and showed that the majority of pre-service teachers found the resources used in the unit were easy to use.

Table 1 Students response (in %) to the statement “This resource is easy to use”.

Resource	Student Responses (%)					
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Number of valid responses
Photostory slideshow	0	2	7	34	57	99
Group space	1.8	3.5	35.1	39.5	20.2	114
WIKI	0.9	10.8	20.7	42.3	25.2	111

The Photostory slideshows were created each week and students could view it as a media file through Blackboard. Students accessed the Wiki resource to reflect on their experiences of product development. The majority of the students believed that the Photostory slideshow and the Wiki were easy to use. Comparatively a smaller percentage (59.7%) either agreed or strongly agreed with the statement that the group space was easy to use. This response is acceptable given that the group space was not compulsory for students to access.

The qualitative data also showed that many believed that some of the resources which they accessed in the course were either useful for the assignment or for future reference (Table 2).

Table 2 Students response (in %) to the statement "This resource is useful for the assignment or future reference".

Resource	Student Responses (%)					
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Number of valid responses
Photostory slideshow	0	1.7	12.8	56.4	29.1	117
Group space	3.5	4.4	36.0	43.0	13.2	114
Wiki	0	7.7	15.4	46.2	30.8	117
Digital video of products	0	0	14.2	46.9	38.9	100

In excess of 85% of the sample either agreed or strongly agreed that the weekly Photostory slideshows and the digital videos of the products were useful for the assignment or for future reference. The majority of the students either agreed or strongly agreed (76.2%) that the Wiki tool was useful either for the assignment or for future reference. The group space was seen as the least useful in terms of its usefulness for the assignment or for future reference. Only 56% of the sample either agreed or strongly agreed with its usefulness. As explained earlier, the use of this tool was not a compulsory part of the course – the optional nature of the activity probably did not motivate students to explore the usefulness of the tool.

Qualitative data gathered from the students provides further evidence on what the students thought about these resources. Students believed that the Photostory slideshows gave them an overview of students of how students built their products in other groups. They appreciated the time that was put into making these resources.

> *Weekly slideshow was awesome. I know it's a lot of work but we appreciated it.*

> *Loved the slideshow. It gave a great overview of what was achieved the week before. This is an idea I am using on my next practicum.*

It appeared that students who used the group space found it useful. According to one pre-service teacher:

> *I loved the way that the group space and Wiki were used. It made doing group assignments loads easier.*

While most students found the Wiki tool to be useful, about 11 % of the sample (see Tables 1) indicated that the Wikis were not easy to use. In the qualitative responses, four pre-service teachers commented that the Wiki would be more useful if it was included as part of the final team presentation. One of the pre-service teachers expressed her thoughts on the Wiki as follows:

Unfortunately the WIKI is a bit of a pain -I do see the point in it now, but I feel like it was a bit of a cut and paste project. It would have been good if it was a part of the actual presentation -used as a tool for explanation. Otherwise I loved this subject; it's really engaging and making a product each week is quite rewarding.

The digital video of the groups' presentations of their final products was seen as useful by the pre-service teachers. These videos were created to give students an idea of what others groups had achieved. It was a resource which added value to the content of the Wikis. Using these resources students commented on another group's product – this was done online through a blog. Students' responses to the digital video were expressed as follows:

Videos fun and helpful to see other ideas.

The video of products will be a great resource for us as future teachers

Videoing the products will be great too because some of these ideas are great and I would love to use them

Discussion

This study focussed on aspects of students learning experiences and the effectiveness of some of the resources they had access to as they unpackaged the technology syllabus. Research has shown that in design and technology subjects there was lack of good examples which demonstrated good teaching practices (HMI, 2004). Preservice teachers also had difficulties implementing appropriate learning because of their limited knowledge of the topic and the syllabus (Stein, Ginns & McRobbie, 2003).

In this course, the workshop activities which students completed appear to have facilitated preservice teachers understanding of the syllabus. The survey administered at the end of week 4, gave an insight into students understanding of the bridge and towers activity. The majority of the students demonstrated an understanding of the nature of the task and how they engaged in the all phases of the Technology Practice cycle. It was interesting to note that students engaged in these phases differently. They were not following the four phases – Investigation, Ideation, Production and Evaluation sequentially but were engaging in these phases is a non-linear manner – as intended in the syllabus document. As they built their products, students were also incorporating aspects of the Materials strand and thinking about other aspects of the syllabus (i.e. context, appropriateness and management). The Bridge and Tower activity showed that the workshop challenges were increasing students' awareness of the syllabus.

The Photostory slideshows were also giving students an opportunity to see how other students were addressing their design challenges. It gave them ideas on how a design challenge can be addressed in different ways, thus emphasising the point that a design challenge can be addressed differently. In one of the activities students were given the following challenge – "Design and make a package that will promote a new healthy snack product and will appeal to children". The packages created varied and images of some of the packages used in the Photostory presentation are shown in Figure 3.

Such an approach gave students ideas as was evident in their qualitative responses *(This is an idea I am using on my next practicum).*

Figure 3 – Examples of containers

The Wiki and the digital videos produced were also perceived by students as effective tools. The Wikis gave students an opportunity to reflect on their experiences. For instance one group which created a rubber-band propelled boat outlined their reasons for incorporating such an activity in a classroom as follows:

> *This design challenge would be suitable for use in a classroom because it a simple yet effective learning activity which uses easily accessible materials and fosters student creativity and ownership of learning. The product being designed is easily relatable to the real world for any students who are familiar with water-based transport and the need for finding alternative means of powering this transport. As such, it would fit well within a larger, integrated unit on sustainable transport and would simultaneously address aspects of the futures perspective cross-curricular priority.*

The group was also able to identify specific requirements in order to ensure the success of the project. They noted the following:

> *The tools and equipment ideally suited to this activity would require additional adult support and supervision (eg. hot glue gun; bowsaw, sidecutters).*
>
> *An appropriate testing facility would be needed (eg. school pool, water trough, PVC piping cut in half, etc)*

Conclusions/Implications for teachers

Design and Technology has not been a priority within the schooling system in Australia until recently. Technology is now one of the *Key Learning Areas* (KLA's) for students in compulsory years of schooling. This article has presented some of the ways in which a Design and Technology unit was presented to a cohort of pre-service primary school teachers.

The pre-service teachers were involved in designing and making a variety of technology products. The pre-service teachers were also involved in designing and creating their own products incorporating the phases of the Technology Practice Cycle identified in the Technology syllabus (Queensland Studies Authority, 2003).

Two particular features of the study can be seen as important in developing the understanding of the Technology KLA. These are the Technology Practice Cycle of Investigate, Ideate, Produce, and Evaluate and the use of resources such as Wikis, Blogs, and digital videos for sharing ideas.

Encouraging pre-service teachers to engage in the same processes that are expected of their future students enables them to create productive innovative learning experiences. It also gives them the opportunity to gain an understanding of the concepts involved in the Technology Syllabus (Queensland Studies Authority, 2003). The team based activities promoted in this article highlight that pre-service Technology units should involve meaningful activities that encourage the students to incorporate the Technology Practice Cycle of Investigate, Ideate, Produce, and Evaluate. The findings also highlight that the use of resources such as Wikis, Blogs and digital videos are integral to sharing ideas within the teams of pre-service teachers and across the unit cohort.

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