Reflective practice: enhancing the outcomes of technology learning experiences

RESEARCH

Anne Fritz

Sydney University, Australia

This research examines the use of reflection to measure the outcomes of technology education in New South Wales, including:

- how school culture and teaching methodology influence learning outcomes
- how confidence contributes to sucess in design and technology activities.

Introduction

This paper is concerned with the act of reflection as a device to enhance learning in design activities. It is based upon the learning outcomes perceived and reported by reflective learners during project-based technology experiences.

The research is set in a well defined educational policy scene. In Australia technology education is guided by the Technology Statement and Technology Profiles (both federal documents); however all seven States are at liberty to have technology education syllabuses that are each unique interpretations of these federal guides. In New South Wales the technology subjects in secondary schools are taught within the Technological and Applied Studies Key Learning Area, which is one of seven key learning areas. These are organised so that students are obliged to undertake some studies in each of the key learning areas, and so graduate at the end of their school years with a more rounded education than in the past. In New South Wales, the subject design and technology has been declared mandatory from 1995, and it must be studied for at least 200 hours by each child between ages 12 to 16 (compared to 400 hours for mathematics in the same time). The syllabus specifies that this subject be taught through projects which are focused on at least six out of ten of the following contexts: health and lifestyle, building, engineering systems, clothing, transport and distribution, agriculture, foods etc. A wide variety of suitable materials and techniques may be used to explore any of the contexts.

The response of teachers to the new curriculum has varied from enthusiasm to resentment. Some teachers have decided to develop new, student-centred units of work in this subject. Other teachers were reluctant to give up their 'control' and preferred to cling to more traditional 'show and follow' ways of teaching, with minor product variations under the title of 'design' The diversity of teacher backgrounds (mainly industrial arts and home economics) and orientations has coloured teachers' reports of the learning outcomes.

Because of the newness of the curriculum and the partisan attitudes of vocal teachers, it has become imperative to gather some fact based information, some valid 'hard data' about the effects of the varied technology learning experiences directly from the students themselves.

Research questions

The first research question was: how to measure the real outcomes of technology education? The most direct answer was to ask the learners "What did you get out of this learning experience? How do you think it will be of value to you in the future?" It is not possible to expect a valid answer to this question. If caught off guard, many 12 year olds would not be able to answer such complex questions clearly and fully, let alone truthfully; their thinking must be guided through their emotions towards deep reflection. The questioning also has to be quite short – no more than ten minutes – and it also needs to be completed while the learning experience is still fresh in the students' minds. Data that has been collected in this way during pilot studies with university and school students has shown the questionnaire below (figure 1) to be reliable and valid, with non-repeat questions and a clear ability to differentiate among students.

The second research question was to identify the correlates of highly successful and valued technology education; the third to identify the road to failure in this area.

Methodology

Students from around New South Wales were asked (and guided) by their teachers to complete the questionnaire at the end of their projects. Nearly six hundred answers were analysed both quantitatively and qualitatively in this first phase of the study. A

Fig. 1

HOW DO YOU FEEL?
(AFTER PROJECT)

Name..... Year.....
School ..... Region .....
Individual or group project: I / G Gender M / F Subject .....
Design Brief for the project:.....
.....
Main materials used for the project:
O wood O food O metal O textile O plastic O components O graphics O other

Circle the answer that best says how you feel about your major project

	extremely what	very some- what	both/ neither	some- what	very extremely	
1	3	2	1	0	1 2 3	...the project was exciting
2	3	2	1	0	1 2 3	...it was not worth all the work
3	3	2	1	0	1 2 3	...I was confident from the start
4	3	2	1	0	1 2 3	...we were told how to do things
5	3	2	1	0	1 2 3	...it was really simple
6	3	2	1	0	1 2 3	...the work was set by the teacher
7	3	2	1	0	1 2 3	... I enjoyed the planning
8	3	2	1	0	1 2 3	... the teacher organised us a lot
9	3	2	1	0	1 2 3	... I was guided through the project
10	3	2	1	0	1 2 3	... I did a lot of research
11	3	2	1	0	1 2 3	... the teacher expected a lot
12	3	2	1	0	1 2 3	... I disappointed myself
13	3	2	1	0	1 2 3	... I did not enjoy the making
14	3	2	1	0	1 2 3	... I did not finish
15	3	2	1	0	1 2 3	... I could have done better

What did you like best about the project ?

What part of the project shows your best work?

What was the most important thing you learnt from doing the project?

What would you do differently next time?

Figure 2

STUDENT QUOTES FROM AWARD WINNERS

"The most valuable thing we learnt was teamwork and how to tackle difficult problems"
"I learnt that if you really put some thought and effort into something, you will be able to produce anything you put your mind to."
"I picked up my sewing skills and I also learnt how to gather my thoughts"
"I learnt that you should always make sure that you can get the things you need in time"
"The most valuable things we learnt as how to organise ourselves, and work in a group"
"The most valuable things learnt during the project were; to compromise when making decisions, and to think of an alternative idea other than the obvious one"
"The most valuable thing I learnt was time management"
"That all detail counts"
"Never say I can't do it, no matter how hard the task is.
"The most valuable things we learnt were: how to design and make something and how we kept asking questions and working it out; plus the group discussions during evaluation."
"We enjoyed making the garden. The most valuable things we learnt during this project were creativity, responsibility and organisational skills."

questionnaire similar to this, termed Experience Sampling Form (ESF) has been used by Csikszentmihalyi (1987) over many years to investigate states of 'flow' and conditions for autotelic activity.

It has been reported by teachers who participated in these reflective evaluations of student learning outcomes, that the reflective activity of filling out the questionnaire helped students to consolidate and bring to their consciousness the learning experience, and hence in itself added to the effectiveness teaching.

The first part of the questionnaire identifies the student, school and project; the second part guides students to remember how the project progressed and how they felt about it (it also provides some oblique identifiers about the style of lesson their teacher was conducting). The final section was then open for the students' free reflective responses about their likes and dislikes, about what they most valued and about what they would change if they could do the project again. Other information was also provided by some willing teachers – the lesson notes/plans, the students' marks, personal comments and evaluations about the class situation.

The student groups included classes in small country schools, city schools, selective and disadvantaged schools, single sex schools, mixed gender schools, private and government schools, and a special accelerant group. There were individual projects, group projects, teacher directed projects and also students' independently conceived projects (these latter for entry into the Minister's Young Designers' Awards).

The marks on the bipolar semantic scale of Figure 1 were used for quantitative analysis while the free answers were coded into categories identified through an earlier pilot project.

Results and discussion

a. Outcomes associated with excellence in design and technology

Students (12-14 years old) who were award winners at the Minister's Young Designers' Awards in 1994 showed in their responses a very clear image of the richness of learning outcomes for those who excelled in their design and technology studies. Examples of what they considered to be the 'most important thing they learnt from their project' are shown in Figure 2.

Successful students were aware that the most important learning outcomes from their project work were not embedded in the context of the project they undertook, but rather they were context free, transferable skills and capabilities (i.e. problem solving, organisational and management skills).

b. Learning outcomes for total sample of 12-14 year old school students

In answer to the question asking for "what was the most important thing you learnt

during the project?", many students (25%) named context-bound practical skills (such as sewing, paper making or the use of machinery) as their most important learning. 7% of the students identified their growing generalised knowledge in the context area (e.g. about healthy eating) as the most valuable outcome, and 10% chose management capabilities as most important. Skills that were clearly identified without reference to a context were classified in the coding as transferable skills (such as group work, planning, independence, confidence in problem solving); these made up 9% of the responses from the 600 students.

When compared with the figures for the successful subgroup, this data indicates that average students are more directly focused on their activities and are less aware of the broader implications of their learning than are successful technology students.

Eighty percent of students offered suggestions about what they would do differently if they had an opportunity to redo the project. A third of the students were concerned with improving their product in some way – 8% thought of some specific changes to the design, a further 8% suggested how they would improve the management of their work, 3% had a specific quality focus and 1% suggested 'designerly' changes in the way they approached the issues.

It is worth noting that overall only 3% of students expressed negative sentiments about their learning experience.

c. The influence of school culture and teaching methodology on learning outcomes

Information from unit outlines at the schools surveyed pointed to the popularity of a 'research, design, make and evaluate' type process for their projects. At this stage it can be stated with some confidence that there were no significant differences between the outcomes of learning of girls and boys, though for some projects in some schools girls were more confident and enthusiastic than the boys, while for other projects in other schools the reverse was true.

When responses were grouped by projects, results clearly showed how much schools/classes/teachers influence the experience and outcomes of learning. For example, students at a fringe metropolitan school were quite 'cool' about their projects, scoring three as neither boring nor exciting (0.3 on a 7 point Likert scale). On the other hand, students at a country school scored their projects as very exciting (+1.62 on the same scale).

The educational orientation of students also plays a part. It is interesting that two groups – one a group of academic high achievers (students designing movable toys at a selective school) and the other an academically outstanding class who are being accelerated through two years of schooling in one year at another school (designing a healthy breakfast) were only mildly excited about their projects (+0.90 average). The gender differences in attitudes were particularly strong in the accelerant class. Relationships between success in academic and in technology subjects will be investigated in an extension of the current study.

When the full data set has been completed over two years (about 4,000 responses), it will be possible to reliably analyse the relative effects of project topic, teacher attitude and the academic orientation of the students. In the meanwhile, responses from the first part of the questionnaire, describing some student attitudes and indicating class organisation, were correlated with the perceived outcomes of the educational experience.

The group of students who, of all the groups, were most enthusiastic, who found the projects most exciting, who were most surprised by their achievements, were also the group who learnt the most management and research skills and who most often reported finishing the task easily. These students were those who in the beginning had the smallest amount of self confidence, and who learnt how to be independent during the project.

The group of students who reported learning to work in groups as the most valuable

outcome of their projects, were also the group who found their projects the most satisfying, their activities the most enjoyable and easy to complete, had the greatest confidence, did most of their research themselves, had the least objection to planning activities and also 'did their best' more than any other group.

The cluster of students which reported gaining (and valuing) transferable skills (including group work, initiative, management and independence) were a large and varied group. The other large cluster were those who nominated context bound, specific skills as the most valuable outcome of their project based learning. There were no statistically significant differences between these two student clusters – probably because of the large size and complex composition of each cluster – but results indicate that they both enjoyed the 'making' activities equally, and surprised and disappointed themselves to equal extents.

On the other hand, the 20 students who had negative attitudes were significantly different from the rest. They were the group with the lowest initial confidence, who reported that they did not learn management skills. They were the ones least satisfied with their own work, who least extended themselves to do their best and therefore were most disappointed by themselves, who perceived their teachers as not expecting much from them, yet found the projects to be boring as well as complicated and difficult to finish – a mutually supportive, complete picture of factors characterising failure in learning.

d. The role of confidence

The confidence of pupils has been identified in Kimbell's APU and SEAC studies (1981, 1991) as an important contributor to success in design and technology activities. Pilot studies with Australian students (Fritz, 1995) have indicated that students with high initial confidence identified transferable skills as their most important learning outcomes to a greater extent than did the students with low self confidence.

In this study, the more confident students thought that the projects were more exciting (q1) and simpler (q5); they were more positive about the planning (q7); surprised themselves more with their achievements (q12), enjoyed the making activities more (q13), finished more easily (q14) and did their best to a greater extent (q15) than did the students who initially had less confidence. This shows how the growth of confidence contributes to the students' enthusiasm for and success in undertaking further learning activities.

The negative responses were higher (5%) among the students with low initial confidence than among the students who started out with high confidence (1%).

Ten percent of the students with low confidence found that the most important outcome of their learning experience was a realisation that they could work independently. This is in contrast to the mere 2% of the already confident students who nominated increased confidence among their most valuable learning outcomes. This indicates that project based learning experiences contribute to a development of confidence which, in time, can change the students' overall attitude to and success in learning.

Management and other transferable skills were more often (34%) identified by the confident students than were identified by students with low initial confidence (25%) as the most important outcomes of their learning experiences. On the other hand, context based skills were mentioned in approximately equal measure (32-35%) by the two groups.

Conclusions

During the analysis of student identified outcomes of technology learning it has been found that:

a) Technology education in the form of the design and technology course contributes to giving students the skills and capabilities most valued in our society; skills of management, cooperation, communication, perceiving needs, facing challenges and identifying ways to meet them effectively.

Students who achieved excellence in design and technology projects perceived that their most valuable and important learning extended beyond the context of the materials and skills for the project. These students were most aware and appreciative of having gained context free, transferable skills like the ability to work in teams, organisational skills, time management and problem solving skills.

b) Technology projects provided a positive learning experience; only 3% of students expressed any negative sentiments about their learning experiences. 80% contributed suggestions as to what they would do if they could do the project again, with many offering ideas for more effective working techniques and for the improvement of their product.

A smaller proportion the total sample of students than of the high achievers identified gaining transferable skills.

Design and technology is enjoyed by students. Whether aware of gaining transferable skills or not, most students delight in the 'making' activities as well as in the fruits of their labours. Many surprise themselves with their own achievements – design and technology is therefore an excellent basis for students to achieve success and motivation for further learning. With increased confidence the students also grow in success, and become more perceptive of the broad applicability of their learning.

c) When the sample was divided according to schools and projects, it became clear that much of the sample variation was based on school culture, teaching methodology and the students' interaction with the specific brief for their project.

d) Confidence contributes to students' enthusiasm and success in undertaking further learning activities; and this research shows that technology project work increases the confidence of students. The greatest personal growth from the learning experience belonged to those students who started with low self-confidence but who learnt to be independent during the project. They were the ones who learnt the most management and research skills and who finished their projects easily.

e) Learning to work in groups was also shown to be an important factor contributing to student satisfaction, achievement and enthusiasm for further learning.

Implications

Technology education in the form of an integrated design and technology course gives students the skills and capabilities most valued in our society; skills of management, cooperation, communication, perceiving needs, facing challenges and identifying ways to meet them effectively. These skills extend beyond the context of the project activities. Students recognise and value them as lifelong capabilities. Successful students of design and technology are particularly well aware of the richness of their learning outcomes.

Design and technology motivates further learning. Students increase in confidence, grow further towards success, and become more perceptive of the broad applicability of their learning.

For all these reasons, success in design and technology is an important goal to pursue in the education of our children.

Group work in technology education is an essential teaching and learning strategy, because it creates maximum student ease, enjoyment, satisfaction, planning, independence, confidence and dedicated work.

Design and technology learning experiences were shown in this study to increase student confidence and independence. Therefore design and technology is an important avenue for motivating students towards goals of self improvement; this is especially true for those students who have not yet discovered their potential.

Further investigations, using a larger (about 4,000 instead of 600) student sample should follow, to enable the detailed identification of factors which contribute to success or failure in technology learning.

References

Csikszentmihalyi, M and Larson, R (1987) 'Validity and reliability of the experience sampling method'. *The Journal of Nervous and mental Disease* 175, (9) 526-36

Fritz, A (1995) 'Education for enterprise capabilities using a technology education framework' – presentation at the 20th World Congress, International Council of Small Business, Sydney

Fritz, A (1995) 'Outcomes of learning through Design and Technology projects in NSW schools'. Design in Education Council of Australia Biennial Conference, Melbourne, September 1995

Fritz, A (1994) 'Reality based education in Design and Technology' *Technology and Design Education* Vol 5 No.1 pp 16-22

Kimbell, R A (1994) 'Tasks in Technology; an analysis of their nature and effects' in the *International Journal of Technology and Design Education* vol 1 pp1-15 Kluwer Press

Kimbell, R A and Wheeler, A (1991) 'Learning Through Design and Technology' (APU) London: School Examinations and Assessment Council .

Kimbell, R A and Wheeler, A (1981) 'Understanding Design and Technology'. Assessment of Performance Unit (APU)