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ORIGINAL PAPER

Factors affecting learning in technology in the early years at school

Brent Mawson

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Abstract The nature of progression in technology is still a matter of debate in technology education. While there is a growing research-based literature exploring the elements of technological literacy that might be appropriate measures of progression, little has been written about the factors that may influence both group and individual development of technological literacy. This article reports the findings of a longitudinal ethnographic study of the progression in technological literacy of 20 children during their first 3 years at school. It focuses on the factors that affected their learning in technology, and identifies a number of personal and systemic factors that affected progression in technological literacy. The implications of these findings for teaching, and for further research are then explored.

Keywords Progression · Technological literacy · Curriculum · Primary education

Introduction

The study was focused on the progression in technological literacy of a group 25 children during their first 3 years of compulsory schooling (Mawson, 2005 Unpublished PhD thesis). The research sought to establish the technological knowledge, understandings and capabilities with which children entered school at age 5 years, how this developed and expanded during their first 3 years at school, and the factors which encouraged, or hindered, learning in technology. This article documents and discusses the only those findings related to factors affecting children's learning in technology.

Technology education is still a fairly new subject globally without a large research base and a well-established culture of classroom practice. The literature tends to focus on specific factors that affect children's learning in technology, rather than

B. Mawson (✉)
Centre for Technology Education, Faculty of Education, University of Auckland, Private Bag 92601, Epsom Campus, Symonds Street, Auckland 1035, New Zealand
e-mail: b.mawson@ace.ac.nz

exploring the range of influences that children encounter as they move through their school experiences. Several themes within the literature were used to give focus to the study and for comparison purposes during data analysis.

The clash between teachers existing perceptions of technology, and the conception of the nature of technology and the scope of technology education which underpins most of new technology curricula around the world has been well recognised (Anning, 1994; Aubusson & Webb, 1992; Compton & Harwood, 1999; Jones, 1998; Jones & Carr, 1992; Jones, Mather, & Carr, 1994; Limblad, 1990; Mittel & Penny, 1997; Paechter, 1995).

There is some literature on effective pedagogy for technology education (Anning, 1997b; Cross, 2000; Hill, 1998; Parkinson, 2001; Stein, McRobbie, & Ginns, 1999). Jones and Moreland (2000) identified the elements as central to effective teaching of technology as being knowledge of the nature of technology and technological practice, knowledge of technological concepts and processes, and general pedagogical knowledge.

Some pedagogical approaches that hinder children's learning in technology have also been identified. An over-emphasis on linear, design-process model for classroom practice has been one area of concern (e.g., Assessment of Performance Unit, 1993; Chidgey, 1994; Fleer, 2000; Hill, 1998; Johnsey, 1998; Norman, 1998; Roberts & Norman, 1999; Welch, Barlex, & Lim, 2000; Williams, 2000). Although the belief that there is a systematic process which can be taught and learned by all pupils who can then apply it to subsequent problems and situations is well entrenched, the literature indicates this is not the case, either in real life or in the classroom (Ferguson, 1993; Lawson, 1980; Norman, Cubitt, Urry, & Whittaker, 1995; Weiner, 1993; Welch, 1999; Williams, 2000). It appears evident that children who experience a linear, design-make-appraise based technology programme may find their learning in technology limited by this approach.

Another widespread teaching approach, the emphasis on drawing designs at the beginning of technological units, has also been challenged. Kimbell, Stables, and Green (1996), feel the belief that design development can only happen on paper with a pencil is one of the commonest and most serious misconceptions in Design and Technology. Stables (1997) suggests the belief that young children can use drawing as a means of modeling and developing ideas may represent an inappropriate paradigm of secondary technology being transferred to the primary sector. A number of studies show that there is a weak link between design and making, and that children rarely refer to their drawings when modeling (Anning, 1993; Anning, 1997a; Rogers & Wallace, 2000; Welch et al., 2000). For many teachers drawing of a technical nature is seen as minor method of communication, and is given little emphasis in their general classroom programme (Anning, 1997b). As a result children lack understanding of the purpose of a design, and lack technical drawing skills (Rogers & Wallace, 2000). Children are often asked to design without knowledge of available materials and their properties (Anning, 1997a). As a result their designs may often exceed their technical skills or the limitations of the materials available to them (Fleer, 2000).

Among other teaching approaches that have been found to detract from pupils' performance is over-specification of the task by the teacher so that the children fail to take ownership of it (Kimbell et al., 1996). The work on collaboration in technology by Hennessey and Murphy has also highlighted the importance of providing opportunities for group work and feedback sessions during which design ideas can be discussed and developed in producing quality outcomes (Hennessy & Murphy, 1999).

The context, and the way an activity is introduced to the student, also appears to affect student's behaviours in technology (Johnsey, 1998; Kimbell, 1994b). The problem context can include the subject matter of the task, the degree of structure present in the task setting and the opportunity for iteration between action and reflection. The effect of the nature and structure of the task on gender and ability levels has also been clearly documented (Kimbell et al., 1996).

Gender attitudes and preferences have also been identified as affecting student achievement in technology education. There seem consistent patterns of aggressiveness towards girls by the boys in the class, which may force them out of participating in the technological activity (Claire, 1992; Riggs, 1994). When working in mixed gender groups girls appear to be disadvantaged. Their opinions are ignored, they tend to be used as technical assistants in practical tasks, and often their reaction is withdraw from the group activity (Claire, 1992; Grima, 2000).

It is suggested that girls have different preferred ways of working than boys. Girls prefer to work cooperatively, and more frequently praise other children's works, and offer help and support (Claire, 1992; Riggs, 1994). Girls prefer contexts focussed on people and their relationship to the technology being developed (Burns, 1997a; Jones & Carr, 1993; Kimbell et al., 1996; Murphy, 1993, 1999). Compared to boys, girls stay more focussed on the problem, are more innovative, and are more ready to take risks, to develop a systems approach to problem solving and develop more appropriate answers (Jones & Carr, 1993). Girls are also seen to do better in more reflective areas of work, and are advantaged in loosely defined tasks that have a strong social context (Jones et al., 1994; Kimbell et al., 1996).

Other factors that impact of children's learning in technology have also been identified. The highly contextualized nature of problem solving, and the need for considerable domain knowledge is well established (Flowers, 1998; Hennessy, McCormick, & Murphy, 1993; Hennessy & McCormick, 1994; Hennessy & Murphy, 1999; McCormick, Murphy, & Hennessy, 1994; Murphy, Hennessy, McCormick, & Davidson, 1996; Murphy & McCormick, 1997). The importance of authentic contexts is also clear (Hill, 1998; Turnbull, 2002).

The study

The study focused on a cohort of 25 children who enrolled at the primary school on or just after their fifth birthday during the period January–June 2000, and who were placed in the same class. An Auckland inner city primary school was chosen as the research site because it had a socio-economic and ethnic make-up that was representative of its geographical area, and it had a commitment to cover all seven areas of the New Zealand Technology curriculum (Ministry of Education, 1995) over a 3-year cycle. Pseudonyms have been used for the children, teachers, and the school.

There were 12 males and 13 females in the initial group. As the focus was on the group interactions as well as individual learning, children who left the school during the data-gathering period were omitted from the final analysis. There were five children, two male and three female, in this category. No children who entered school after June 2000 were involved in the study. The nine teachers who had the children in their class during their first 3 years of schooling were also involved in the data gathering process and the parents/caregivers of 13 of the children also agreed to participate. In the first year of the study all the children were in the same class. In the second year they were spread between three new teachers. In the final year of the study the children were spread over six classes. One of these classes was taught by a teacher involved with the children in year two, but she had different children in her class than were with her the previous year.

The context and the nature of the participants also dictated the data collection methods. As one part of the data collection involved the six school technology units it was important to collect all the documentary data such as unit plans, design drawings, and written assessment tasks completed by the children. The children's technological practice in the units also had to be documented, and this was done through video-taping their classroom work, audio taping class and group discussions and post-unit interviews with both the children and their teachers, and photographing emerging and final solutions to the particular technological task.

As gaps in the evidence emerging from the classroom activities became apparent, targeted technological tasks were also carried out with all, or some children. These were videotaped when a practical task was involved. Written or drawing tasks were collected, and were annotated or field notes made at the time the task was undertaken.

In most cases, interviews to explore the children's initial knowledge and understanding of technology were held during their first month at school, before they began their first technology unit. This was not possible with five children due to delays in gaining the signed permission slips. In these cases the interviews took place immediately the permissions were received. The interview covered pre-school experiences, use of electronic technologies, and understanding of the use and operation of every day technology. There were also some simple construction and problem-solving exercises in this interview to give an indication of their level of technological capability.

The parents of 13 children also agreed to be interviewed at this time. A semi-structured interview covered the parents' perceptions of their child's early childhood education experience, cooperative and leadership behaviours, preferred learning styles and problem solving ability, competence and experience with electronic equipment, tools and utensils, level of curiosity and attitude towards technology education and the parents' own understanding of technology.

Triangulation is a research technique at the heart of ethnographic validity (Ely, Anzul, Friedman, Garner, & Steinmetz, 1991). Triangulation depends on the convergence of data gathered by different methods. Triangulation in this study is satisfied by collecting data over a period of time and making use of multiple and different sources and methods to provide supporting evidence.

Within the limitations imposed on a sole researcher in the second and third years of the study with multiple dispersed activities occurring at the same time, an attempt was made to record all relevant data. These were collected in a number of forms (videotape, audiotape, original and photocopies of written work, photographs, field notes) and using a number of data collection methods (interview, observation of classroom activities, targeted practical tasks). Respondent validation was obtained from the teachers and parents who were given the transcripts of interviews to check for accuracy and to modify as required. Different viewpoints on the purpose of the units, teaching approaches, and the learning resulting from them, were gained through the teacher interviews. The parent interviews were very useful in evaluating the accuracy of the children's self-reported experiences at home and in early childhood education settings.

As the children's reading ability was limited, I was unable to give them transcripts of their interviews for them to verify. I attempted to validate the children's voice in three ways. The use of semi-structured interviews allowed me to seek clarification of their responses and to explore in depth individual differences. Whenever it was possible I discussed with children the thinking behind their design drawings and written material and annotated the document at the time. During practical tasks I discussed with children their reasons for the actions they were taking and made field notes to record their responses.

As the study progressed I regularly reviewed the data, and the method and form in which it had been collected. When I identified gaps in data, or reliance on a single source of data, I applied another data collection activity to give wider coverage.

The particular challenge was to find an appropriate means of analysing the learning in technology that occurred in the first 3 years of school. The elements of technological literacy identified in *Technology in the New Zealand Curriculum* (Ministry of Education, 1995) were used as the initial framework for data analysis. The validity of the eight levels of progression contained within the technology curriculum statement had not been researched in New Zealand at the time this study commenced. I was therefore prepared to modify the framework of data analysis in the light of emerging data and new literature. During the period of the study further matrices of progression in technological literacy emerged from the Learning in Technology Education—Assessment (Jones & Moreland, 2003), Technology Education Assessment—Lower Secondary (Compton & Harwood, 2004b), and the Technology Exemplars projects (Ministry of Education, 2003). Although all of these were seen as research based advances on the levels of achievement in the 1995 curriculum statement, none of the three matrices gained general endorsement. In view of this I developed a global approach to data analysis in that I took each child's data from a unit of work or a targeted task, and used all four matrices to provide indicators of the learning in technology that had taken place. As all four categorised technological literacy in different ways I decided to report the finding within two categories, technological knowledge and understanding, and technological capability.

The individual and group case studies were examined at the end of each unit and targeted task for common patterns of progression, and for factors that might explain these patterns. Some of these factors were suggested by the literature, for example gender, the nature of the technological tasks, and teachers' constructs of technology. Other factors that appeared to affect the children's progression of technological literacy emerged from the study itself. The number and nature of these common factors changed during the study as more in-depth data analysis was completed, and as my understanding of technological literacy developed.

Findings

The limitations posed by the small sample size, 20 students in one school needs to be borne in mind with regard to the findings of the study. The factors that affected the learning in technology of these children fell into two categories. The first group of factors affected individual children. These were their general level of academic ability, personal disposition to risk-taking, home experiences and gender. The second group was systemic in nature and affected all the children. These factors were the school planning process, teacher constructs of technology, and the requirements of the compulsory Technology Curriculum. Pseudonyms are used for children's names in the reporting of findings.

Personal factors

Academic ability

The children's potential academic achievement on entering school was indicated by the data gathered with the School Entry Assessment (SEA) tests (Ministry of Education, 1997). This is an instrument designed to assess new entrants' skills in early literacy, early numeracy, and oral language. It is administered one month after entry to school. All the children in the study were given the tests at the appropriate time after entering school, providing a measure for comparison at the start of the study. It would seem that the literacy and numeracy levels with which a child enters school are reasonable indicators of achievement in technology during the early years of schooling. This was particularly so for children with low SEA scores. For children with high and average SEA scores, other factors such as, personal disposition, home environments, and gender may also have an affect. Although all the children became more literate and numerate during their first 3 years at school, for most their relative literacy level within the group did not significantly change. Individual ranking on the Progressive Achievement Test (PAT) in Listening Comprehension, one of a series of standardized, nationally normed PAT's administered in March 2002 (year 3), was only significantly different from that of the School Entry Assessment data for 2 of the 20 children.

A judgment was made of each child's level of technological literacy at the end of their third year at school. The relative achievement of the children was compared for all the technological units, the tasks in the initial and final interviews, and for those targeted tasks that all children were involved in. The grade given for technology by their classroom teachers on the reports to parents at the end of each year was also taken into account. This analysis showed that the children appeared to fall into three groups with regard to technological literacy (Table 1). The first higher achievement group of seven children contained four children who also appeared within the first seven places in the ranking developed from the School Entry Assessment data. The six children with the lowest level of technological literacy, with one exception also correspond with the seven lowest children on the School Entry Assessment ranking.

Personal disposition toward taking risks in technology

The data indicates that personal disposition toward risk-taking is a significant factor in achievement in technology. Carr (1997, Unpublished Ph.D) identified this as an important feature of children's technological practice in an early childhood education setting. She explained children's different reaction to problems in technological activities as related to a discourse for performance or a discourse for learning. Carr saw a conflict and tension between a desire for 'correct being' or 'belonging' (discourse for performance) and desire for exploration and agency (discourse for learning). Children motivated by performance goals responded to difficulty by either

Table 1 Comparison of School Entry Assessment scores, Progressive Achievement Test of listening comprehension and ranking in technological literacy

Name	School entry assessment (2000)				PAT listening comprehension	Technological literacy (Nov. 2002)
	Rote counting to 100	Words recognized	Letter names recognized	Letter sounds recognized	Class percentile	Level
Margaret	13	3	8	23	33	Average
Elizabeth	24	NS	7	11	45	High
Heather	38	10	5	27	83	Average
Catherine	2	0	4	6	25	Low
Penelope	20	NS	11	25	49	Low
Sarah	27	NS	13	24	83	High
Wendy	30	9	8	19	25	High
Theresa	20	NS	0	8	37	Average
Olive	12	NS	9	23	71	High
Linda	12	7	7	21	25	Low
William	12	4	7	16	33	High
James	0	0	0	4	15	Low
Simon	12	5	5	9	54	Low
John	100	10	37	28	71	High
Harold	14	NS	0	6	41	Low
Charles	16	8	3	18	63	Average
Peter	12	2	0	5	86	Average
Paul	10	3	1	0	18	Low
Henry	39	10	14	26	NA	High
David	12	8	5	16	NA	Average

Notes

1. NS—This task was not administered to these children
2. NA—David and Henry were under the lower age limit for the test at the time it was administered
3. Scaled score indicates the present level of achievement of a student in terms of the content and skills tested

to ignoring it, avoiding it or retreating from it. There is evidence that learning dispositions are enduring. Performance goals are associated with being right in school.

A discourse for performance, and disposition against risk-taking and innovation, was evident in a group of five girls and one boy, and it limited their achievement in technology. This disposition was shown in a number of ways. These children usually were reluctant to start a technology activity when working alone, copied other children's ideas, kept asking the teacher for guidance and reassurance, and produced low-level solutions. They consistently maintained these behaviours during the 3-years of the study. Personal disposition was the prime factor in Heather and Penelope not achieving a level of technological literacy that might have been expected from their SEA ranking.

A positive disposition to risk-taking seemed to be a major factor in allowing children to achieve a level of achievement in technology higher than might have been predicted from other indicators such as SEA score and achievement in other curriculum areas. This was clearly evident with relation to Elizabeth, Wendy, Charles and William.

Home influences

Out-of-school experiences clearly enhanced children's technological practice, although it was difficult to quantify this. The strongest evidence of this link is within the data relating to William. William consistently referred to his home environment when explaining where he got his ideas. In the tenting unit a group of children in his class was attempting put up a tent. There were no instructions with it and the children in the group were unable to work out how to erect it. William came over from his group, which was constructing a shelter and showed the tent group how to do it. When asked how he knew this he replied, ''I know how to put it up because I just understand how to put my brothers up, it's the same thing.... I put my brothers tent up in the weekend'' (Interview, 22/3/02). When explaining where he got his ideas for strengthening the platform in the final interview he said that he, ''Got the ideas from my uncle because he's a builder, from Rush Hour2 (video) for the bamboo, from home for the string'' (Interview, 11/10/02). When accurately and rapidly putting the electrical circuit together in the final interview he commented, ''My uncle's a mechanic so I'm quite good at doing this stuff. I watch him fix my mum's car'' (Interview, 11/10/02). Earlier in the same interview while drawing a cube using an algorithm he said, ''I just copy what my dad does''.

The three girls who produced complex birdhouses in year one had all worked in wood with their father earlier in the year at home. Margaret had spent two weeks helping her father build a tree house at home earlier in the year and had worked with wood, and used saw, hammers and nails in that process (Interview, 9/11/00).

The data indicate that involvement in home activities with a male relative, particularly one who worked in a trade, was more significant that involvement with a female relative. However, this may just be a reflection of the nature of the technological tasks undertaken by the children during the period of the study. Had there been units involved with food technology or soft materials then female out-of-school influences might have been more evident.

Gender

Gender does not seem to have been a significant factor in determining the level of achievement in technology among this group of children. The data from the initial interviews with the children and the parents indicated that the boys came to school with a wider range of experience in using tools and hard materials, both in the early childhood setting and at home. This was also apparent in a boat building exercise carried out in March 2000, at which time 17 children had entered school. The children had a choice of wood or cardboard with which to make their boat. Of the nine girls only one (Wendy) chose to make her boat in wood, whereas all eight boys made theirs in wood (Field note, 13/3/00). This gender difference was closed later in the year in the Birdhouse unit, in which all the children used wood to make their structure. In general the girls produced more complex structures, and their level of workmanship was equal to that of the boys.

The three groups identified with regard to level of technological literacy at the end of the 3 years are virtually gender balanced. The one group that appear to make some greater progress are the middle academic ability boys such as Charles and William, who show greater conceptual and procedural knowledge than girls of a comparative academic ability. However, this difference seems more readily explained in terms of personal disposition, home experiences, and the nature of the tasks than as a gender-based outcome.

Systemic factors

The school context

As the research project developed it became evident that there were a number of factors within the school context itself that were having a major impact on the children's achievement and progression in technology. Three of these seemed to have wider implications and the discussion will focus on these factors.

The New Zealand Technology curriculum document identifies seven technological areas (Ministry of Education, 1995, p. 12). These are Biotechnology, Electronics and Control technology, Food technology, Information and Communication technology, Materials technology, Production and Process technology, and Structures and Mechanisms. In Years 1–3 children are required to have experience in four technological areas (p. 29). The school-wide method of planning often seriously compromised the technology units during the 3-year period. The school, like many others, organized its curriculum delivery around a theme for the term. Once the theme was decided, (e.g., living things, natural forces) one or two staff would then develop a unit plan for the whole school in each of the curriculum areas to be covered that term. The individual curriculum units were related to the theme, and, if possible, to other units of work to achieve some degree of integration. The Technology unit also had to fit into the technological area set down for that particular year in the school scheme. The teachers would then meet in their various year-level syndicates to refine and adapt the plan for their own classes. This posed a number of serious problems for Technology, which does not have an identified content and a well-defined progression of knowledge and skill acquirement within the curriculum statement. It was difficult to set authentic tasks because of the constraints of the theme and the technological area. The isolated method of planning meant that no consideration was given to knowledge and understanding gained in previous technology units. Thus there was no planned progression and development of generic concepts and skills.

Another problem was that none of the teachers in year one and year two were among the staff who developed the technology plan, and often the task set was not appropriate for their class level. The teachers, who had not been a party to the thinking behind the unit plan, also had problems in interpreting the learning outcomes and understanding the underlying purpose of the task. Most did not have a strong personal construct of technology, and did not see professional development in technology as important.

Furthermore, as the technology unit often followed the science unit and was linked to it, this sometimes resulted in units that were applied science rather than technology. For example, in year two of the research project, a science unit on growing plants was followed by a biotechnology unit on mushrooms. The science unit focused on children developing their own gardens in the school grounds. These ranged from flower gardens to herb and vegetable gardens. The technology unit was related to growing mushrooms in a straw-growing log. The straw, mushroom spore, hydrated lime and growing bags were purchased from a grower who specialized in providing the resource for schools. Because of the cost only one growing bag was available for each of the 19 classes in the school. As a result, in many classes the class teacher did the actual preparation of the growing log with the children watching. For two of the three classes in the study this was done by the teachers after school so that the children did not see the process of soaking the straw in a hydrated lime solution, and the packing of the sterile straw and mushroom spore into the growing bag. The children's involvement in the unit in most cases was confined to viewing the log at irregular intervals and researching and filling in work sheets on mushrooms.

The children themselves when questioned about the unit and the activities they had undertaken were able to talk about the structure of mushrooms and identify different types. Of the 21 children spread over the three class only one girl was able to make a connection to the process of manipulating the growing environment of the mushrooms, which was the biotechnological aspect of the unit. Sarah was a member of the class who had been able to see and take part in the initial setting up process for the growing log, and she was able to describe all the steps involved. When asked why the straw was soaked in the hydrated lime solution she replied, "To get all the bugs out of it. Because otherwise they'll eat the mushrooms." For most of the children they could see no distinction between growing their vegetables and flowers and growing the mushrooms.

A second major factor influencing the children's learning in technology was the way in which individual teachers taught the unit. The delivery of any common unit could vary quite markedly from classroom to classroom. In their second year at school the children undertook a technology unit on Warning Devices. As this followed a science unit on volcanoes the scenario for the technology unit was related to the danger posed by a lahar resulting from a volcanic eruption. Although the three teachers involved were using the same plan and had discussed it in a syndicate meeting, children in the different rooms clearly had very divergent experiences within this common unit.

In Mary Black's room children worked within a non-authentic, fantasy context to design warning devices that were not modeled or critiqued for practicality and effectiveness. Any making was carried out using inappropriate materials and was not related to the purpose of the unit. In Ellen Grey's room children worked individually to produce a model of a warning device that was contextualized within the children's own neighbourhood and which related to the overall purpose of the unit. However many children failed to achieve a successful outcome. This was largely due to the totally hands-off approach of the teacher, which forced children having problems to rely on input from other children. In June Green's class children worked collaboratively on practical solutions that were clearly situated within an authentic social and environmental context. The designs had been evaluated against clear criteria, and the children, with an understanding of the relevant constraints involved, carried out the selection of the designs to be pursued. All four groups in this class achieved a workable solution to the problem.

Technology and Society is one of the three strand in the New Zealand Curriculum statement (Ministry of Education, 1995, pp. 41–43). This covers such things as children developing an awareness that people hold different views about technology, a recognition that some existing technologies are expressions of social and cultural values and the ability to identify the different ways the use of technology affects people and the wider living and physical environment, including awareness of unintended consequences. Although an important focus of my data analysis, none of the data collected during the 3 years gives any indication that these ideas were beginning to take hold among the children as a group. Some individual children may have been developing these ideas, but if so it would have been as a result of out-of-school activities, as these concepts were not integrated into the school technology units.

The wider educational context

There were a number of educational factors external to Mayflower school that impacted on its technology programme and affected the learning of the children. The nature of the Technology curriculum has already been mentioned in the discussion of the school planning system. The non-prescriptive nature of the document, and the emphasis on technological areas for programme planning made effective implementation of the new curriculum area difficult for the school.

Wider political decisions also impacted on the technology education programme of the school. In 2001 the National Administrative Guidelines (Ministry of Education, 2001) were amended to require each Board of Trustees give ‘‘priority to student achievement in literacy and numeracy, especially in years 1–4’’ (NAG1 [I][b]). The National Administration Guidelines for school administration set out statements of desirable principles of conduct or administration. They also describe requirements relating to planning and reporting that communicate the Government's policy objectives. As language and mathematics were given more prominence in years 1–4 the other curriculum areas were relegated to the afternoon to jostle for time not only with each other, but also with the myriad of other activities that occurred in the school; assemblies, sports days, cultural visits, parent days etc. The impact on technology of this change of government policy was quite dramatic. When the school was chosen as the site for the research project there was one 4-week and one 2-week technology unit each year. Four years later this had been reduced to one 2-week unit.

The Technology Curriculum was first introduced for schools to trial in 1995. The Ministry provided substantial professional development programmes in 1996, 1997 and 1998 to support the implementation of the curriculum. Mayflower school had partially completed the Know How 2 professional development programme in 1997, and the two teachers with a leadership role in technology had also undertaken personal professional development in technology education. Since that time very little professional development in technology had been available as the Ministry of Education concentrated its resources on supporting the implementation of the three new curriculums (Social Studies, Health and Physical Education, The Arts) that followed the technology curriculum. During the 3-year period of the study one of technology curriculum leaders left the school, and the other had a year's leave, leaving nobody in the school who had an interest in the subject, or who had a deep understanding of technology education. The lack of professional development opportunities made it difficult for the school to improve the situation.

The relative level of technological literacy for any child within the group after 3 years of school was in most cases a reflection of their general academic achievement. Individual divergence from this trend were most clearly related to their home experiences and their disposition to risk-taking. The progression of technological literacy of the group of the whole appeared to be limited by a range of systemic factors that were beyond the control of the children. A wider study which included children in other schools may have provided some indication as to whether this limitation of learning had occurred, and to what extent.

Discussion

While this study was set in one school only, my own observation in over 50 primary schools, and anecdotal evidence from my students returning from practicum, leads me to believe that the delivery of technology in Mayflower school is representative of that in many Auckland schools. The data gained in this study identifies three main areas that may need to be addressed by schools with regard to implementing technology.

The first of these is concerned with the planning of school-wide programmes. As is also the case with science and the arts, a reasonable time allocation needs to be given to technology if real learning is to take place. This is particularly true of technology in which the process is a key element. It takes time to understand the problem, to explore a range of possible solutions, and to present a well-justified, appropriate outcome. Without this level of engagement technology units tend to become ‘‘making’’ craft activities. New Zealand schools are faced with increasing demands to extend the taught curriculum, and it is unlikely that many schools will be able to devote the time needed for technology. The best solution to this time constraint may be to use the essential cross-curricular nature of technology to produce genuinely integrated units that would provide authentic contexts for learning in all curriculum areas. It is likely however that the technology component would be lost in such integration as many teachers do not have a strong personal construct of technology. This has implications for in-school and externally delivered professional development programmes.

A second key change would be to create a school technology scheme that ensured that generic knowledge and understanding was carried through and built on from one unit to another. The present curriculum document, which lays out coverage of technological areas as the basic requirement for schools as far as meeting the planning needs, has tended to result in a series of stand-alone units from year to year. As a result children struggle to see what ‘‘technology’’ is and they are given no opportunity to develop a coherent knowledge and skill base. The draft matrix developed to support the technology exemplars (Ministry of Education, 2003) provides a solid starting point for any school wishing to develop a programme which would allow children to successfully develop competency in the components of technological practice as they progress through the school. However, the matrices have become a casualty in process of reviewing the Technology curriculum as part of the revision of the New Zealand curriculum framework (Ministry of Education, 2005) Official policy is now aligned with the components of technological practice developed by Compton and Harwood (2004) which also provide an alternative model for schools to use in long-term programme planning. There has been some criticism of the process that led to the rejection of the matrices (Davies, 2005), and technology education in New Zealand seems to be in a state of flux at this time. The removal of the requirement that coverage of a specified number of technological areas as different stages within schooling in years 1–13 be the basis of school programme planning that is contained within the draft Technology Essence statement is a major step forward.

A key element in technology education is the development of a critical or liberating technological literacy (Burns, 2000). The lack of reference to the interrelationship of technology and society in the units of work in this study highlights concerns expressed by Burns (1997b) and Mawson (1999) that the Technology and Society strand in the Technology curriculum would be lost in the delivery of technology units in the classroom. Participation in a technological society demands an understanding of the ways technology is changing society, and children will need an understanding of the societal processes involved in the production and use of scientific and technological knowledge in order to provide an appropriate critique of it. The value-laden nature of technological practice and the need for children to develop an understanding of this is clearly stated in the New Zealand Technology curriculum statement (Ministry of education, 1995, p. 41). It is vital, therefore, that children are given the opportunity to explore the underlying values issues when carrying out a technological activity, and that these opportunities are clearly evident in unit plans. A key factor in this is to integrate these investigations into an authentic technological learning experience. Without this integration, coverage of the interrelationship of technology and society when it occurs often takes the form of an isolated project-type investigation with little connection to the technological activity itself (Mawson, 1999). This is another area in which a concerted professional development programme is needed.

There is a need for some consistent, long-term professional development in technology education for classroom teachers. It is now a decade since the draft curriculum was published and schools began trialing it. Our understanding of the nature of teaching and learning in technology has dramatically advanced since that time. However with financial constraints, and the needs of the other areas as new curriculums have been introduced, very few teachers have had any recent professional development in technology education. There is as yet no ‘‘staffroom culture’’ for technology as exists in the other longer-established curriculum areas. It is not a common topic of teacher discussion and sharing of ideas and knowledge. More use could be made of teacher support services and pre-service educators to develop school-based professional development programmes for staff. Opportunities could be made for staff to read and debate current research-based articles on technology education. The standing of technology within the school would be enhanced if leadership in the area were given to someone with power and standing in the school community. With the quite fundamental changes to the present curriculum document foreshadowed in the revised New Zealand Curriculum Framework the need for a comprehensive professional development programme is even more pressing. It is unlikely, however, that there will be the same financial and human resources available to support the introduction of the revised curriculum and the supporting material that will accompany it as was allocated when the curriculum was first introduced as revised version of the other six curriculum statements will also be introduced at the same time.

The changes to the Technology Curriculum that have been signaled in the draft Essence Statement (Ministry of Education, 2005) will go some way to resolving some of the systemic difficulties discusses above. Planning should become more coherent once the requirement to base it on the technological areas is removed. The progression of technological practice presently contained in the draft essence statement offers a clearer, if more linear (Davies, 2005) guide for planning and assessment in technology. However, much of the philosophical thought which underpins the curriculum revision will be totally new to most teachers and there is a real likelihood, given the probable lack of professional development to accompany the implementation of the revised curriculum that classroom teachers will find it very difficult to change their practice in line with the new document.

Two areas seem to offer real opportunity for schools to develop a programme that provides more authentic technological experiences for their students. Firstly, more use needs to be made of community resources. In some cases in this study, for instance the Warning Devices unit, children lacked sufficient prior knowledge to be able to solve the problem. If units are set in contexts unfamiliar to the children then care needs to be taken either to provide prior in-school experiences, or planned opportunities provided within the unit, that will enable the children to gain sufficient knowledge to be able to understand the nature of the set task. Mayflower School made very little use of human and material resources in the community when planning or teaching their technology units. The children would have produced more appropriate technological solutions in the Warning Devices unit with input from suitable people involved in the field. This is one area where primary schools could learn from their early childhood colleagues. Relationships with family, whanau and the wider community is one of the underpinning principles of the early childhood curriculum *Te Whaariki* (Ministry of Education, 1996) and the close relationships that develop between early childhood centres and the wider community play an important part in providing high quality educational experiences for the children. As well as tapping in to community resources, a greater use of the out-of-school experiences and knowledge and skills that the children bring to school with them as a starting point for unit planning would both enhance the quality of the technology units but also provide opportunities for teachers to develop a socio-cultural pedagogy and a classroom environment in which a collaborative culture could flourish.

This study has identified a number of areas that would profit from further research. The link between prior-to school experiences and school achievement needs to be explored. What technology experiences do children have in early education settings? How are they related to school technology experiences? How effectively do early childhood teachers recognize and enhance children's technological play? All of these are under-researched areas. Even less well researched is the relationship between home and community experiences and children's technological literacy. Some clear links have been identified in this study, but much more research needs to be done in this field.

The study has also suggested that a personal disposition to risk-taking is a key element for successful learning in technology. This raises other questions that need pursuing. Are there other dispositions that are similarly important? How and when is a disposition toward risk-taking formed? Can such a disposition be fostered in young children? All these questions need to be addressed as we seek to understand how young children start the process of becoming technologically literacy.

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