Application of an Analytical Framework to Describe Young Students' Learning in Technology

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This paper discusses a framework for describing and analysing how young students (5–6 years) learn in technology with a view towards enhancing teaching and learning practice in technology. Examples of student work which demonstrate the complexity of learning in technology, and what young children can achieve with appropriate teaching strategies are presented. Holistic aspects as well as associated variables are highlighted.

Introduction

There are several aspects of technology which can present a challenge for the young learner, for example, maintaining a focus on the end point of the technological activity, transferring information from one technological task to another, understanding the purpose of the various design stages, to name a few. A considered approach by teachers, taking in such aspects as appropriate task selection, clearly defined learning goals, scaffolding and linking, appropriate student teacher interactions and keeping the end goal in focus during learning, can overcome many of the challenges and assist young children to achieve beyond current expectations in technology. Using a case study approach the teachers featured in this paper used a holistic approach to planning and assessing technology education, such as the one shown to be successful for teachers involved in the LITE (Assessment) project (Moreland, Jones & Northover 2001).

The LITE (Assessment) project

Learning in Technology Education or LITE (Assessment) was a three year project which first investigated and later enhanced primary teachers' ideas and practices regarding teaching and assessing in technology education. It was noted that although teachers demonstrated knowledge of technology education in terms of technological strands and areas, and appropriate activities for technology, this knowledge lacked depth and detail. They compensated by confining their teaching to activity based technology, rather than focusing on technological concepts and outcomes. This in turn affected their assessment practices because, lacking robust technological concepts, they based their formative interactions and summative practice upon factors such as general and social aspects. It became clear to the researchers that in order to address their primary aim of enhancing assessment practices in technology education; they must first address the technological knowledge of the teachers. The LITE (Assessment) intervention stage (Moreland et al 2001) began in the second year. It involved fifteen teachers (all of whom demonstrated a sound general teaching pedagogy) including two teachers of five-year-olds, or Year One students. The primary focus was to target the teachers' formative interactions with their students by ensuring the interactions assisted their students to move forward technologically. In order to achieve this it was important to assist teachers to enhance their own knowledge of technology and how to teach it. One strategy was the development of a framework.

This framework which describes the categories for learning in technology, allowed teachers to specify concise intended learning outcomes as they planned their technology, and to keep these learning outcomes foremost as they interacted with their students throughout the technology process. The framework became the focal point for planning and for guiding formative interactions and analysing student learning. The framework successfully assisted teachers to clarify concepts in technology, and identify and address their own knowledge gaps prior to teaching. They could ensure that their learning outcomes reflected a balance across conceptual, procedural, societal and technical aspects, while understanding the yielding nature of the barriers between. This in turn impacted upon formative interactions with their students, which became increasingly technological (and useful) because the process of planning had clarified the teachers' ideas about learning intentions and the technology within the task. Better understanding of technology allowed them to be discerning but flexible, and able to deal with unexpected technological learning that arose during the learning process. Very apparent was an enhancement of student performance in technology education resulting from these improved interactions.

The third year saw a widening of focus to include targeting teachers' summative strategies (Moreland et al 2000). It was important to ensure that the teachers and researchers had a shared understanding of summative assessment, which went beyond an overview of previous learning. Not only should summative assessment involve accumulation of evidence collected over time, and coverage of previous learning, but should also suggest where future directions for learning lay. Summative assessment practices by LITE teachers needed to be meaningful to a wider audience than the classroom teacher and student, such as school and outside management, parents, successive teachers and other relevant parties, although the focus was in classrooms.

Related to this was the accumulation of student work gathered, throughout the technology learning process, which was given sharper focus during 2000. Considered portfolios of work in technology, with accompanying commentary and analysis, were found to be a powerful tool in assisting teachers to enhance summative assessment understandings and practices. A significant development during 2000, was a profile for recording summative data about individual students, which was closely linked to the planning framework shown in Figure 1, and included holistic statements about learning in technology. At the end of the three-year project, the teacher participants were enthusiastic about their progress. This was reflected in the following comments which teachers made as they looked back over their three-year involvement in the research project.

> My planning, and formative and summative assessment practices have made huge strides. I am able to take some of these ideas and adapt them into other curriculum areas.
>
> My interactions with the students are more detailed, focused and far more specific. My children have knowledge of where they are going.

The LITE (Assessment) project met its main goal of enhancing the teaching, learning and assessment practice of primary school technology teachers (Moreland et al 2000), affirming the desirability of an integrated approach to planning teaching and assessment (Harlen 1994). This paper presents some specific strategies used to teach technology in classrooms with young learners by technology teachers. An example is presented demonstrating the successful use of strategies and includes selected student work.

Strategies for teaching technology with young children

The New Entrant room is a unique point of transition between Pre-school Education and formal schooling, and as such has a learning focus which can probably not be found else where in the school. One of the difficulties for technology is that language development; both oral and visual is central to all curricular covered. This means that technology receives minimal attention. A further complexity is that the level of performance of New Entrant students is hugely variable, as are their interests, their rate of learning and their competence socially. This in itself can be problematic, and in terms of assessment and evaluation there is the challenge of attempting to analyse their understandings without being restricted by limited or non-existent writing skills. Effective teaching strategies and management are all important in identifying the conceptual and procedural understandings that these children have achieved. With these complexities in mind several strategies need to undertaken to enhance student learning.

Enhancing the performance of young students in technology education

Increasing numbers of studies in recent times have attempted to analyse the designerly thinking and design capabilities of these young students and to identify strategies which will enhance learning in technology at this early level. To find these studies we need to search broadly into the areas of Technology Education, Art and Craft, and the cognitive development of pre-school and school age children. As a result of data analysis of the LITE project, the New Zealand National Exemplar Project in Technology Education, and an ever-increasing range of international writers, valuable teaching strategies for technology teachers working with young students has become apparent.

Task selection

Young students engaging in technological activity need to be working within a known environment, and carrying out real and familiar tasks. Designerly thinking in young students begins as designerly play in which children interact with their environment, playing, making and exploring ideas. Design occurs as part of the unfolding drama created by the children and may or may not result in a tangible outcome (Coghill 1989). In school based design activity where there is an expectation for a design solution or artefact, working within a context in which students feel confident and already knowledgeable, will ultimately enhance their ability to engage in tasks and their overall performance. Carr (2000) refers to the importance of anchoring tasks to everyday meaning to improve achievement.

Student drawing

Similarly with the drawing and design work of young students, children prefer to draw what is familiar, what gives them pleasure, and what they have drawn or experienced before (Thomas & Silk 1990). Drawings tend to be representations rather than an accurate reproduction of the topic or object depicted (Thomas & Silk 1990), and children also tend to draw what they know rather than what they see (Freeman 1980). This obviously has implications for the accuracy and the usefulness of the images children produce in their technology planning.

End point focus

Strategies for maintaining a focus on the end point of the technological activity is another ongoing challenge for junior room teachers. Stages within the design process tend to become end points in themselves, i.e. a design drawing becomes a colourful representation of a design solution but without intentionally informing its construction. The reasons for this are varied but one solution is to make very clear to students the purpose of the activity they are involved in (Anning 1992; Fleer 2000). For example, if they are drawing a plan of a kite they are about to make, they need to understand why they are drawing it, i.e. it could be to help them decide what their solution will be, to list materials they will require, to decide on joins and construction methods, or to provide a basis for formative interactions with their teacher. The drawing activity must have a clear purpose to make it meaningful for students and then inform their final solution. As Matthews (1994) states, it is never too early to discuss with children how their images work: it is just that one has to vary one's use of words according to the child's age.

Mismatch between planning and construction

Linked to this feature of young children's design work is that final solutions often do not resemble plans or design drawings (Rogers & Wallace 1998). When teachers employ strategies which keep the final solution and the eventual product user central to the technological development, children seem more likely to maintain their focus on developing useful solutions (Kimbell et al 1996). At the beginning of each session, for example, it is useful to review previous work and refocus students on the task ahead of them, providing them with reminders of early discussions, decisions made, and referring them to wall displays, pictures or charts which summarised previous sessions.

Modelling and planning

Closely aligned with this discussion is the 2D versus 3D debate in early design work. Stables supports the idea of 'hands on exploration' and in particular that which provides a basis for ensuing design work. The advantages of young children 'playing around' with materials and then constructing their ideas through 3D models circumvents the difficulty of trying to translate 2D flat images into a 3D prototype or model (Stables 1997). In a study in which children's ability to model clay was compared with their 2D design work, it was shown that their competence improved when working with clay. Their models showed side and frontal perspectives, unlike their 2D drawings, and most attempted to achieve verticality or stand-up models. The mix of views that are often seen in children's drawings are thought, as a result of this study, to be a consequence of the problems set by the 2D medium rather than students' lack of understanding of the relationship between these views (Golombe 1997). Giving students the opportunity to handle materials that are available for them to use, and to construct prototypes through trial and error, would appear to be a more useful design sequence for young students (Stables 1997; Anning 1992). In addition, providing time and materials for undirected playing and making during the daily programme, will further enhance students knowledge and capabilities

Information transfer

Transferring information from one technological task to another, and from one stage within a design process to another is also problematic for young students. Crisafi and Brown (1986) investigated analogical transfer with two and three year old students and found that young children were able to transfer learning from one situation to another in certain circumstances. One of these circumstances was to ensure that children recognised the similarities of the tasks previously carried out. Learners need to "notice" similarity and "apply" the rule (Crisafi & Brown 1968). In the classroom it is a matter of making links for students, e.g. "Remember when we talked about", or "Remember when we saw".

Consideration of variables

The final point worth particular mention is young students' inability to consider more than one or two variables at any one time. Siegler (1996) discusses the unidimensional and multidimensional thinking of young school age students and believes that five year old students tend to reason unidimensionally and that there are conditions that seem to promote this level of thinking. For example, (i) unfamiliar tasks; (ii) tasks which require a quantitative comparison–more, less; (iii) tasks which require a discrete choice between two or three alternatives–red, yellow, blue, or (iv) tasks which include a single dominant dimension which can lead children towards specific incorrect answers (Seigler 1996). This suggests again, that task selection for young students is critical and should be chosen from a familiar context and involve the development of a familiar artefact or device as its solution. Tasks should be sufficiently challenging and open ended to allow for multiple solutions, but should only include a small number of unrelated variables.

It is clear that working with five-year-old students offers challenges to technology education that are not as apparent with older age groups. It is also clear that successful and meaningful technology activities can be achieved with these students if the process they are working through is carefully managed, tasks are appropriate, formative interactions and considered methods of gathering and analysing their work are employed. Regular undirected opportunities to practice and refine their skills should be an on-going part of every classroom programme and strong links to the integrated approaches of Early Childhood programmes will allow students to work in a preferred multi-curricular way (Lambert 2000). Technology Education is a natural flow-on from the imaginative and designerly play observed in any Early Childhood environment.

Example to demonstrate successful technology teaching

Example 1: Developing a photo frame with a standing or hanging device

This discussion is based around a technology unit taught by an experienced teacher in technology, with a group of twenty-two New Entrant students. The technological area in which this unit was situated is Structures and Mechanisms. The New Zealand curriculum defines this as including a wide variety of technologies, from simple structures, such as a monument, or mechanical devices, such as a mousetrap, to large, complex structures such as a high-rise office block, or mechanical devices such as a motor car (Ministry of Education 1995).

As part of the New Entrant students' initiation into their new classroom, the teacher took digital photographs of each of the students to display on the classroom wall. The technology unit linked into this activity. Students were invited to make hanging or standing photo frames in which they could take their photographs home when the display was changed. The primary focus of the unit was the selection, design and construction of the hanging or standing device of the photo frame, with the design and construction of the frame being of secondary importance. The task selection was all important. In this case an interest in the photographs had already been created and the desire to take them home was unquestioned. The idea of developing a photo frame with a hanging or standing device so that the photos could be safely transported and displayed at home was a task within the grasp and interest of the students. Photo frames were a familiar artefact in their lives, and the students already had an understanding of their purpose and function. The teacher's planning was detailed and identified student learning in terms of the LITE framework mentioned previously, i.e. conceptual, procedural, societal and technical knowledge.

The first stage of the unit involved several sessions where students shared and built upon existing knowledge. They looked at a range of commercially produced photo frames, identified appropriate materials which they could work with, and discussed the concept of "frameness"–what is a frame, what is it's purpose and how does it function?

The following work samples were selected from a range of students participating in this unit and were analysed according to the framework described previously. It also includes a teacher scribed summary of students' prior knowledge. Each sample selected shows a stage that is of significant in the technological process.

1. Conceptual Development

As an introduction to this unit, the teacher took time to discuss the idea of making a photo frame for their class photo. She also spent several session discussing children's existing understandings of a photo frame, how a photo frame functions and identifying some of its most import features. The students were generally immersed in the topic, with discussions, collections of frames, books showing how to make frames, and then beginning the focus onto the criteria for making their own frame and support device. These charts summarise students' prior knowledge and their ideas about the selection of appropriate materials to make their photo frame and support structure. This gives a useful overview of the understandings and ideas these students have without being restricted by their limited writing abilities or having to take time to record individual responses. The conceptual understandings of these students are quite clear: They are beginning to use appropriate descriptive language, (plastic, protection, wiggly lines), and they have a beginning understanding of some technological principles, i.e. aesthetics, (decorations to make [the frame] look good); stability, (not floppy) and rigidity, (not bendy or twisty). They are able to identify appropriate materials and they have an understanding of the function of the frame, i.e. the photo goes behind the glass, [the frame] goes around the photo, and [the frame] covers the white bit on the photo.

2. Initial Planning

The next stage of the unit involved re-focussing students on the development of their own photo frames and support devices. Firstly the task was clearly defined and then students and teacher listed what they considered they must include when making the frames. This established the criteria which students needed to consider in their design work. The next session involved identifying materials that the students had available to them and which would be easy for them to manage. A final chart centred on the decoration of their photo frames. Whilst this was not a focus of the technology, it was something the children were expecting to do. The work shown demonstrates procedural and conceptual understandings. Students were able to use the appropriate technological language, e.g. corflute, plastic, and tin foil. They understood the purpose and function of the photo frame, i.e. it was to display a photograph, to protect the photograph and to look attractive. They began to talk about two methods of displaying the photo frame, and were able to select appropriate materials for the construction of their own frame and support structure. They were also beginning to express understandings of technological principles and were able to relate conceptual understandings of existing frames to the design of their own photo frame.

3. Children's Frame Designs

This was a critical session in terms of management strategies to support these very young students. The session began with a recap of the previous discussion on materials for photo frames, followed by the introductions of the day's task, i.e. to draw a plan for their own photo frame. The purpose of the plan was discussed and links made to other plans they had seen, e.g. the plan to make a small sailing boat in one of their shared books. They discussed how a plan was different from a drawing and how you should draw a plan, i.e. pencil drawing with labels. They also recapped on the criteria for their constructions. Two pieces of student work examined, showed that the children have an understanding of the whole task, i.e. one student had included the cardboard piece from which the frame is going to be made, a plan of the front and a plan of the back. Both of the plans showed an understanding of the purpose to which the frame will be put, e.g.

the inclusion of the rectangular or oval window in the middle of the frame through which the photograph will show. The children had a beginning understanding of how to draw a plan, i.e. it is to tell other people your ideas so needs to have labels. They understood the function of the frame and how it relates to the support structure, i.e. the inclusion of the standing mechanism in each of the drawings. The plans were drawn in 2 dimensions and the children were able to select appropriate materials for the task, i.e. cardboard, thread, paper, ice cream lid or corflute.

4. Support Mechanism Plans

In this session students were to make a plan of the support mechanism for their photo frame. They had previously looked at a collection of frames that included a wide variety of hanging and standing mechanisms. Students recapped on the discussion of how to better display the photos, they considered where the photo frames were going to be displayed and they thought about the concept of stability, or not wobbly, in terms of their standers or hangers. They recapped again on things to consider when drawing the plan. Two examples examined were of a hanger and a stander. The children had a clear understanding of the task. Some of them were able to select a solution for a particular purpose, e.g. Jack said, "I am making a hanger so my baby brother wont get it" [the photo frame]. They were able to communicate their ideas with a 2D drawing and were able to select appropriate materials for the task, i.e. cardboard and string. They were able to transfer ideas from a previous session and apply them to their designs, e.g. metal clips to hold the back of the frame on, cardboard hooks, and parcel tape to hold the frame together.

5. Frame Construction

Translating 2D design drawings into a 3D structure was the focus for this session. This is considered to be a very challenging task for young children, but in this case, the image drawn, although 3D as a construction, was relatively flat, with only a front and back view to consider. The teacher carefully stepped her students through the following stages: a recap of the previous discussion about materials which the children could use, a close look at the inside shape of their photo frames, i.e. where the photo would go and how it needed to be slightly smaller than their photo. They also looked at the selection of pre-cut cardboard, corflute and plastic and then teacher demonstrated how to draw around a photo to determine the correct size for the inside shape. The children worked on this task in groups of five or six whilst other class members were occupied with another activity. Most wanted to work independently but a teacher aid was available to help with difficult cutting and the use of the glue gun.

The finished examples demonstrated students' procedural and technical knowledge. They were able to select appropriate materials for the task, and they understood the purpose of their design drawings in terms of guiding their final construction work. They demonstrated the use of basic technical skills, i.e. the use of scissors, making straight cuts, and following a pattern. They were also able to consider, and later talk about, the criteria selected earlier, i.e. protect the photo, the frame to go all around the photo, have decorations, look good, be strong and include a photo winder smaller than the photo. As is frequently observed with young children, their design ideas for decorations were mostly abandoned. The teacher in an earlier session had invited children to bring along decorations to use on the construction day. Sadly the carefully drawn rockets, dogs and patterns were exchanged for stick on silver stars, shiny stones and golden bows brought along to school by enthusiastic parents.

6. Support Mechanism Construction

The purpose of this session was for students to translate their 2D drawings into a 3D structure for supporting their photo frame. The final constructions demonstrated learning similar to that shown in the previous session. A significant difference was in the way students kept to their plan. There were no distractions of glitter or silver paint, just a stander or a hanger that needed to work. There was an air of diligence and determination to successfully complete this part of the job.

7. Teacher Summative Assessment

The photo frames were finished and the children presented them to the rest of the class. They had an opportunity to share interesting details and the teacher encouraged the children to ask questions of each other. She also talked about the process they had worked through and how it was a technological process. Her final task was to record summative statements about each child's practice and the progress that had been made throughout the unit. She had kept all student work including their initial ideas, homework investigations, annotated plans, and photographs of their final solutions. She also spoke individually with each child throughout the unit and used prepared templates to focus her discussions. These doubled as a record of their understandings, as well as a place to record anecdotal teacher notes. Summative statements were written based on the key learning outcomes identified in the unit plan, the criteria set by the children and their teacher, and how this was reflected in their final construction. The finished photo frames were greatly prized by children and parents alike, and now reside proudly on top of various pianos, bedside tables, and sideboards.

Conclusion

To enhance and sustain learning in technology there needs to be a focus on teacher knowledge of specific and technological learning outcomes in conjunction with appropriate pedagogical approaches. These pedagogical approaches must take account of beginning school children and the particular strategies that are need with this group of students.

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