Multimodalities in primary school mathematics with ICT

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Abstract

School curriculum documents now include applications of ICT as a subject in its own right or as a component in most subject areas. However there is evidence that many classroom teachers do not integrate ICT into non-computer subject areas. Until recently the cause of this phenomenon was reported as a combination of poor access to appropriate hardware and software, and a lack of professional development for classroom teachers. In 2008 neither of these factors should be significant today in Europe, the United States or Australia, although the problem of providing appropriate and ongoing professional development has not been solved for all teachers.

It is typical in school education for teaching and learning to been considered as linear processes, usually evidenced by scope and sequence charts displayed in curriculum documents and textbooks. As educators in the first decade of the twenty-first century, we understand and accept that there is usually more than just one single path between where a learner is cognitively at this moment and where they might be following the creation of new knowledge. ICT has the potential to enable and encourage both teachers and students to explore a variety of non-linear paths.

In this paper some of the problems associated with the various modalities the students work with as they understand, interpret and communicate the concepts they have engaged with in a variety of modalities are considered. In 2007 primary school children were set tasks that involved representing things multimedia formats. This involved combing written description, written labels, icons, a digital photograph, computer-generated shapes, and animation. The children worked in pairs at a table in the classroom, in the school library or at a computer.

Introduction

Results of Australian students in the OECD PISA study (Thomson & De Bortoli, 2007) indicate some downward trends in achievement and understanding, notably a decrease in performance of 15 year-old students in reading literacy, and in mathematical literacy among females. Research discussed in this paper set out to investigate the efficacy of types of ICT in promoting transmediation in primary school classrooms, defining transmediation as “the generative process of translating meaning from one system of signs to another” (Smith, 1997: 4).

In the early 20th century C.S. Peirce developed a concept of signs that is still employed in order to make meaning and to communicate (Smith, 1997). Peirce’s semiotic concept of sign consists of an object that stands for something because it creates in the mind an equivalent sign that stands for the object. Researchers have begun to revisit this concept and its links to the sociocultural concepts of Vygotsky. Bonds between Peirce’s semiotics and constructivist mathematics teaching were explored by Smith (1997). Since then “transmediation” (Semali, 2001), “essential literacies” (Jones, 2007) and “multimodalities” (Jewitt & Kress, 2003) also appear to have evolved from Peirce’s concept.
Recent research questions the dominance of reading and writing in most language curricula, usually to the detriment of newer modes of communication. Jewitt and Kress (2003: 3) state that “there is no monomodal communication, and set out to challenge the implicit assumption that speech or writing are always central and sufficient for learning”. For classroom practitioners this implies that literacy has been reconstituted for students of the twenty-first century.

The research that informs this paper was conducted in schools in metropolitan Melbourne, Australia. The mandated curriculum, the Victorian Essential Learning Standards (VELS), contains evidence that the developers were aware of multimodality and so extended their concept of literacy for learners. In the preamble to the English curriculum it is stated that the fundamental concepts are “texts and language”, with texts being defined to include literacy texts, multimodal texts, media texts, workplace texts, and everyday texts. Each of these forms of text is defined: “In English, the modes of language are reading (including viewing), writing (including composing electronic texts), speaking and listening. Multimodal texts are those that combine, for example, print text and spoken word as in film or computer presentation media” (VELS, 2007).

This project is loosely based on research questions claimed by Jewitt and Kress (2003: 3) to be the basis for the studies reported in their book. Those questions were modified to suit local context and to focus on types of ICT used for teaching and learning in mathematics. The first focus of the research is on the potential of aspects of ICT to promote learning and meaning in mathematics through transmediation. In particular the study aimed to investigate whether the affordances of some ICT can enable teachers to make changes to teaching strategies and assessment regimes by constructing “analogous meanings in sign systems which are different from the sign system(s) used to deliver the original messages” (Smith, 1997: 4).

VELS is structured such that ICT is an interdisciplinary domain that extends across every subject area. It is expected that all subjects will make appropriate use of a variety ICT. In addition, the ICT domain is subdivided into three dimensions, one of which is “ICT for communicating.” This implies that not only will ICT be used across the curriculum at all levels, but also that communication will be one focus of ICT for all students.

Throughout 2007 the author made weekly visits to a primary school to work with three classes. Each session for the research lasted 50 minutes and took place in the library, which provided both a writing area with tables and a suite of 15 computers. Because the school is quite small, 350 students, each school term the classes from a different level participated in the research.

**Activities and discussion**

In this section three different activities carried out with classes of primary school students are presented together with some examples of work created by students and a brief discussion. The first mini-study relates to tasks performed by
students in grades 1 and 2 (aged from 6 to 8 years), the second to grades 3 and 4, and the final mini-study to activities for grades 5 and 6. The activities used with the students were related to the mathematics curriculum, and were designed to engage students in different representations of a mathematical concept.

**Mini-study One: Representing three dimensions of a flat screen**

Using LCSI “MicroWorlds” students in grades 1 and 2 were introduced to some geometric concepts through a directed exploration of a simple microworld called single-key Logo. The purpose of this microworld was to simplify the usual Logo commands for moving a turtle. The microworld enabled students to use F or B to make the Logo turtle to draw straight lines, and by entering R or L to turn at right angles. They quickly began experimenting with combinations of these commands. In weeks 8 and 9 of the term children were presented with two challenges based on using a procedure that drew a large rectangle. The procedure drew a rectangle of fixed size and orientation.

In week 8 they were asked to drag the turtle to a position towards the bottom left of the screen so that the rectangle procedure, RECT, could draw a rectangle without going off the screen. For most pairs of students this took some practice, but eventually was accomplished. The children were then told that the rectangle represented a building, and they were to add any features they wanted and to make a background. An example from one pair of children is shown in Figure 1a.

![Figure 1: Anna and Aleksanda’s drawings of buildings using the RECT procedure.](image1)

**Figure 1a:** Street scene with the RECT procedure.  
**Figure 1b:** Creating rectangular prisms.

The second task was planned as a cognitive challenge in both perception and execution. In math classes students had been making and building with cubes and rectangular solids. In one class the researcher presented a large rectangular prism with each side painted a different colour. The prism was passed around and children were encouraged to turn it over and look at the different colours on the sides. This was followed by a discussion of which sides could be seen, and where sides of a nominated colour were located. The children were seated in a semi-circle and the coloured prism was placed on the floor. When asked which side or sides they could see all of, there was considerable surprise that not everyone saw the same colours.
This was followed by a computer-based task in which students used the rectangle procedure from the previous week to create the illusion of a 3-D solid on the computer screen. As can be seen in Figure 1b, what children did was not always mathematically accurate, with much not being anticipated by teacher or researcher. Making the rectangles and joining corners turned out to be a relatively simple exercise, however determining which lines to delete caused problems for most groups. Colouring the faces to represent the rectangular prism also created considerable confusion, discussion and argument.

**Mini-study Two: Money and value in multimodalities**

Of the three activities discussed in this paper, this one was considered by the researcher and the class teachers to be the least successful in terms of student learning outcomes. The aim was to use the concept of value, mostly in terms of monetary value or cost, to represent concrete materials students were familiar with, in particular base 10 multibase arithmetic blocks (MAB).

![Figure 2: Base 10 multibase arithmetic blocks.](image)

![Figure 2a: Components of base 10 MAB.](image)

![Figure 2b: Lining up small blocks with a long.](image)

The grades 3 and 4 students appeared to have few problems making sense of MAB tasks when working with numbers as opposed to values. For example, given a pile of MAB they could work their way through the process of replacing ten small blocks with a long, or replacing ten longs with a flat. However when a value was apportioned, such as a long costs $1, students had problems changing from a purely numerical construct to one based on money. From discussion with some students it appeared that they did not fully understand the concept of conversion of amounts of money. One such example was the difficulty students had in determining the number of $2 coins they could exchange for two $5 notes.
**Mini-study Three: Properties of regular polygons**

Because this study had operated for more than eleven years, by the time students reached grades 5 and 6 they were experienced with turtle geometry in MicroWorlds. In particular they had constructed regular polygons several times for different reasons, but the mathematical properties of the polygons had never been fully explored, especially, relationships between angles and sides.

Many students in primary school have difficulties with the concept of “angle”, at least partly because it is often presented as an abstract concept. Because a sound understanding of “angle” is necessary when considering the mathematical properties of polygons, students in this study undertook activities with the specific aim of confronting angles and angular measure in a variety of modalities.

The vertices of three regular polygons (triangle, square, hexagon) were marked on the playground. Students walked around the polygons, and at each vertex were encouraged to consider issues including whether the amount they turned to face the next vertex was greater or less than a given reference – initially the corner of a rectangular piece of cardboard. In later sessions the reference was replaced with a large wooden protractor graduated in multiples of ten degrees, and students were asked to quantify the amount they needed to turn.

Using “MicroWorlds” the students produce many regular polygons. As they were experienced users it was quickly agreed to use a template in the form:

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repeat number-of-side [ forward length-of-side turn-left-or-right outside-angle]
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which enabled a lot of exploration. In their maths book students sketched the regular polygons and dimensioned the sketch with the side length and angle.

![Figure 3: Examples of regular polygons](image1)

Students produced and analysed many regular polygons by changing the number of sides and angle of turn, or by changing the length of the sides. Talking about what properties had been found became a regular part of these classes. Angles were a particular focus: interior/exterior, same/different, larger/smaller.

At the end of the three lesson unit students appeared to have a sound understanding of what angles are and how they are measured. In addition they had discovered relationships between the interior and exterior angles in the various polygons, as well as between the number of sides and the exterior angle.

![Figure 4: Exterior angle](image2)
Summary and Concluding Remarks

Summary
Although this is not being presented as a completed project, the results obtained so far indicate that there is value for learners in representing mathematical concepts in various ways using different modalities. The examples presented in this paper have used ICT-based multimedia activities that in most cases involved learners generating a product.

In future research lessons will be analysed at several layers. Categorising lesson events has been used previously to provide researchers with an outline of what occurs in a lesson. Pedagogical strategies employed by teachers when they use ICT will also be investigated. Finally, the nature and style of interactivity between teacher, learners, and the ICT used will be investigated. Both teachers and students will be interviewed to ascertain their perceptions of the process, nature and depth of learning that occurred.

Conclusions
Children in the early years of formal schooling can develop understandings of mathematical concepts through activities that use ICT-based multimodalities. The multimodal representations, whether ICT-based or not, need to be supported by teacher led questioning and discussion aimed at encouraging the learners to think more deeply about the mathematical concepts they have been exploring.

In order to have effective teacher led questioning and discussion, teachers must fully understand the concepts being learned as well as the intricacies of how children learn and develop deep understanding of such concepts. In lesson observations at the start of this study it was unusual for teachers to regularly have some form of plenary time at the end of a lesson that involved students using ICT. On the rare occasions when a plenary was observed, it would always focus on aspects of the hardware and software that had been used rather than the concepts that had been explored.

Finally, most schools already have and use on an everyday basis software that is capable of being used to investigate multimodal representations. While a lack of equipment is not a barrier, adequate teacher training and preparation is.

References


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