Engagement versus Deep Mathematical Understanding: An Early Career Teacher's Use of ICT in a Lesson

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This paper describes how an early career teacher used technology in a lesson about capacity utilising calculators, a bank of PCs and an Interactive White Board. Data analyses of the digital recordings of the lesson using a framework for classroom practice indicated mostly student-centred learning and opportunities to experiment and talk about their activities. However, there was limited evidence of deepened understandings of mathematics. Findings from this study warrant further investigation into the usefulness of a tool to refine classroom practice.

Since the late 1990s there has been increasing support for the integration of technology in the curriculum in policy documents. Yet, in 2005 many completing a preservice teaching course at an Australian tertiary institution indicated that they had rarely observed innovative uses of computers during their practicum. Indeed, many of the examples described were drill and practice type games for early finishers or lessons involving rotations of activities, one of which was a computer game, which was often unrelated to the topic being taught. None of these practices were consistent with the advice offered in their mathematics education coursework.

The case reported in this paper is from a small study investigating two research questions:

How is this novice teacher, who completed an Australian undergraduate primary teacher education degree, using technology in his/her teaching of mathematics?

- How effective is the teaching?
- ICT in School Teaching and Learning Contexts

In recent policy documents such as the *Victorian Essential Learning Standards* (VELS) (Victorian Curriculum Assessment Authority, 2006) greater recognition has been given to *Information Communication Technologies* (ICT). The domain is classified within the *Interdisciplinary Learning Strand* which encourages *ICT for Visualising Thinking, Creating and Communicating* (VCAA, 2006). There are various ICT applications and types of computer software available for teaching and learning contexts across disciplines. These applications range from programs which provide practice for a skill that has been previously taught to those which develop conceptual understandings through problem solving.

More specifically, there are several reasons for incorporating ICT into mathematics instruction. According to the National Council of Teachers of Mathematics "Electronic technologies …furnish visual images of mathematical ideas, they facilitate organizing and analysing data, and they compute efficiently and accurately. They can support investigations by students in every area of mathematics. When technology tools are available, students can focus on decision making, reflection, reasoning, and problem solving" (NCTM, 2000, p. 24).

Studies such as Clements and McMillen (1996) reported positive outcomes for students who used computer programs that were open ended, encouraged discussion and solving problems, and supported the development of conceptual knowledge. Similarly, Wall, Higgins and Smith (2005) used a template of a classroom scene with blank speech and thought bubbles to collect students' views of how ICT can be used to aid learning. The templates were used with groups of four to six students much like a focus group; however, students could complete their template in their own way: for example, some added extra bubbles or detail to the scene to illustrate the meaning. Wall et al. (2005) reported that students held positive views of using *interactive white boards* (IWB) for learning and identified eight subcategories for facilitating learning which included: understanding, concentration, students' use of IWB, present information, games, assists remembering, easier, and thinking process.

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Wall et al. (2005) noted that the majority of students "commented on how the visual and verbal elements complemented each other and promoted effective learning" (p. 860) and that "many of the positive comments linked IWB use and mathematics with fun and games" (p. 861). Hence, Wall et al. suggested that IWBs may be useful tools for initiating and facilitating the learning process especially given students' views.

Reynolds, Treharne and Tripp (2003) challenged findings of studies which imply that the use of ICT causes higher levels of student achievement. Instead, they argued that often increased student outcomes are evident in schools where subject review and assessment procedures drive curriculum and ICT is integrated across teaching and learning areas; and, in cases, where ICTs are used by staff who have been provided with effective in-service training.

Similarly, Zevenbergen (2004) described two cases in which teachers from different socio-economic schools used ICT differently. In one example, the teacher, who worked in a school with students from socially disadvantaged backgrounds, clearly modelled the steps needed to complete the ICT related skills or activity however; there was no evidence of discussions between teacher and students linking the ICT activity with the conceptual understanding of the mathematics. In contrast, another teacher, who worked in a school with students from middle socio-economic backgrounds, modelled his thinking, used various conceptual representations and engaged students in meaningful discussions about their uses of ICT and mathematics.

Sutherland, Armstrong, Barnes, Brawn, Breeze, Gall et al. (2004) noted that many year 4 students already knew how to manipulate programs such as MS Excel even though they had never been taught at school. Hence, a mathematics lesson modelling the use of the MS Excel program did not address the students' needs. Their findings also indicated similarities in everyday classroom practices leading to the successful integration of ICT. In many cases, students were "engaged for sustained periods of time in activities that related to what the teacher intended to teach" (p. 422). In contrast many of the less successful cases of embedding ICT into subjects involved teachers who believed that simply using ICT and appropriate software would be sufficient. Sutherland et al. (2004) concluded that collective and critical discussions are essential for students to learn how integrating ICT tools contributes to the development of subject knowledge and subject culture, in other words, what is discipline-specific valued knowledge.

It seems that although in many cases schools are equipped with computers, they are not utilised to their full potential. Lerman (2004) reported that teachers were reluctant to use innovative activities with students who displayed behavioural issues. Furthermore, that "one does not often see innovative work using technology in any area of mathematics, with any groups of students" (p. 622). Instead, students who were perceived to have poor mathematics skills were often given more of the same activities of the kind that they had failed before.

Zevenbergen and Lerman (2006) reported findings from a three-year study involving six schools representing the diversity of Australian communities. The focus of the project was to "identify the ways in which ICTs were being used in the classroom" (p. 594). Zevenbergen and Lerman reported that there were varied levels of ICTs usage between the schools; however, there was relatively limited use of programs to support numeracy learning and that generally teachers indicated greater confidence in using ICT for literacy than for numeracy learning. They concluded that teachers need to feel more supported if they are able to use ICT in their classrooms. They argued that this was particularly important for students who enter schools with less ICT-experience than their peers.

Zevenbergen and Lerman (2007) used the *Productive Pedagogy* (PP) (Gore, Griffiths, & Ladwig, 2004) framework as a basis for data analysis for the use of ICT in upper primary classrooms. Data indicated that when teachers used ICT to support numeracy learning there were very low levels of quality learning potential. However, results were even lower when teachers used interactive whiteboards. Zevenbergen and Lerman (2007) concluded that "the use of interactive whiteboards actually reduces the quality of mathematical learning opportunities, provides fewer opportunities for connecting the world beyond schools, and offers little autonomous/independent learning opportunities for students" (p. 859).

Zevenbergen and Lerman (2007) also posited that as a consequence of teachers using the pre-prepared lessons for the interactive whiteboard and/or the in-built tools and features of the interactive whiteboard itself, the pace and focus of lessons may attend less to the specific needs of students as they arise during the delivery of the lesson.

In summary, findings from studies reviewed indicate that some experienced teachers find it challenging to integrate ICT into lessons and deepen mathematical understandings. Hence, it seems important for teacher educators to investigate this issue.

Data Collection, Analysis tool and Approaches

The 60-minute mathematics lesson reported here was digitally recorded during Term 3, 2007. The footage was later analysed by researchers using an existing classroom observation schedule and protocol (Gore et al., 2004; Zevenbergen & Lerman, 2007).

Digital recordings of classroom practice have been widely used to capture ways in which teachers transform theories and policy directives into their own classroom contexts. These recordings may be used for various purposes and audiences. Mousley, Lambdin and Koc (2003) argued that providing technology within teacher education programs brought theory and practice closer together and allowed preservice teachers to consider personal theories about pedagogy. They offered three different purposes for using technology in teacher education: first, to study teaching practices by viewing resources such as, videotapes and multimedia resources; second, to enable preservice and in service teachers' opportunities for professional development and communication; and, third, to use electronic resources such as calculators and computers for doing mathematics.

On one hand digital recordings of classroom practice provide opportunities for repeated viewings, on the other hand there are known limitations using this source of data. There are issues affecting reliability and validity both in the data collection and analysis phases such as having additional people in the classroom observing the lesson and then using an appropriate tool and consistent protocol to analyse the data.

Several steps were taken to address these known issues and to reduce their effects. Three of the four researchers met with each teacher and class prior to the day of recording and explained the purpose and process of the exercise to minimise the impact of foreign agents to the context. The fourth researcher did not have any contact with the participants at all. This step was planned to add another layer of critical objectivity in the data analysis stage.

Gore et al. (2004) provide items and key questions that address each of the PP framework dimensions. The framework identifies *intellectual quality, relevance, supportive classroom environment,* and *recognition of difference* as four dimensions of classroom practice that are essential for student learning. The schedule includes items which elaborate each dimension, for example, *Intellectual Quality* includes items *higher order thinking, deep knowledge, deep understanding, substantive conversation, knowledge as problematic, and metalanguage*.

The PP framework was used by each researcher to ensure consistency in data analyses. At the first data analysis meeting the research team discussed each item and dimension to gain a shared understanding of the schedule. This also involved a critical and collaborative review of the footage of one lesson to become more accustomed to the schedule. Following this session, each of the researchers independently viewed and completed the PP schedule with the scoring system ranging from 0 to 5. A value of 1 indicated minimal evidence of the dimension and 5 indicated a strong presence of the dimension throughout the entire lesson. At the third data analysis meeting, researchers shared their scores and debated differences until consensus of scores was achieved for each dimension.

Results and Discussion

This section presents data from the digital recordings of one lesson in two ways: first, as a descriptive snapshot of the events; second, as an analysis of the classroom practice using the PP framework. Pseudonyms are used in the paper.

Julia, a novice teacher in her mid-twenties, has three years teaching experience with Preparatory classes in an Australian school situated in a predominantly middle-class suburb. In 2007, Julia's class comprised 18 students all of whom were native speakers of English. Everyone, including the teacher, appeared happy, calm and settled. The classroom environment was inviting, stimulating and well-organised. There were four computers in the classroom specifically for student-use situated along one wall. Students worked at tables clustered together and sat in a space at the side of the room for whole-class activities. The IWB was located in another room in the same building which was available for class bookings.

An Overview of the Lesson

Figure 1. Story read and discussed.

Figure 2. Explanation of Task A.

The 60-minute lesson followed the *whole-small-whole* lesson format. As depicted in figure 1, for the whole-class introduction, Julia read *Alexander's Outing* (Allen, 1993) a story about a duck that strays from his brood, falls down a hole and helpful passers-by rescue him. Next, she led a class discussion about how Alexander was helped out of the hole. The introduction was interesting and the discussion was focussed. However, at no stage did the teacher mention the words *volume* or *capacity*. The key point Julia made was "that the hole had to be filled with water all the way to the top; otherwise, Alexander would not have been able to get out."

To commence the small format of the lesson, the teacher explained two tasks which were to be completed in pairs as shown in figure 2. Task A required students to estimate first and then use plastic containers, scoops, water and plastic ducks to imitate Alexander's rescue. While one child filled the container with scoopfuls of water, the partner used the constant function on the calculator to keep record of the number of scoops used to float the plastic duck to the top of the container (figure 3). These counts were then recorded on the class recording sheet (figure 4).

Three points were emphasised in Julia's explanation and demonstration: the difference between a full and partially full scoop of water; the need for careful recording of each scoop using the calculator's constant function, i.e. one press of the equals key for one scoop; and, to estimate and record the number of scoops of water required to fill the container before the measuring commenced. The explanation was clear and students were on-task, yet, there was still no mention of the terms to describe the mathematics topic.

Figure 3. Measuring and counting

Figure 4. Recording estimates and final count

Figure 5. Galaxy Maths capacity acitivity

For Task B students worked at the four computers and took turns with selected activities from the software program *Galaxy Maths* (Sunshine Multimedia, 2000). It was evident that students had prior experience with computers and these short activities which explored the concepts of volume and capacity. The commentary from one activity included the following instructions: 'Click on the containers in order, from those which hold the most to those which hold the least.' In another game: 'How many cups do you think will fill the container? You have a guess and then Number Cruncher will have a guess.' It seemed that students were having success with the activities which sought an estimate given an informal measuring unit and various shaped vessels.

Following the paired activities, the whole class gathered again on the floor and some students shared their experiences of completing Task A. The following excerpt is between Child A and Julia:

Julia: Show us the container that you used to measure, to save Alexander from.

Child: (Holds up a small plastic jug).

Julia: How many scoops did you estimate it would take to save Alexander, to fill the container?

Child: Ten.

Julia: And when you measured, how many was it?

Child: Ten.

Julia: And was that more, or less, or the same?

Child: The same.

Julia: The same. Good boy.

The same questions were used with several students. In each case, the focus seemed to be on the number. The relationship between the number of scoops and the differing sized containers was never mentioned. Similarly, students were not asked to compare the results from the measuring exercise with another nor to make generalisations.

For the remaining 15 minutes of the lesson, the class moved to another room where they completed *The Mud Cake* story and three activities from *Galaxy Maths* (Sunshine Multimedia, 2000). The class looked on as various students interacted in turn with the IWB.

Figure 6. Child using IWB.

Figure 7. Classmates and teacher observe.

It was obvious that the students enjoyed the activities on the IWB even though the same programs had been used in their classroom. As mentioned earlier, these activities provided opportunities to estimate and check given various scenarios which appealed to children. It was disappointing but understandable that when Julia asked the class, "what maths have we been learning?" that one or two students mentioned counting yet none mentioned capacity or volume.

To address the second research question, these data are examined a second way. Table 1 presents an analysis of the lesson using the PP framework. The final column of the table indicates the duration the items were evident in the lesson. Scores of 3 - 4 indicate that the particular item was evident throughout the lesson for approx. 30 or 40 minutes respectively, whereas 0 - 1 indicate that the item was not apparent or only for approximately 10 minutes in the digital recording of this lesson. These data suggest the teaching practices contributed to developing a positive and *supportive school environment* which is an important ingredient for learning and that the activities were relevant to an extent. However, amongst other points, the intellectual quality of the mathematics learning was limited.

Table 1

Presence of Items From the Productive Pedagogy Framework in Julia's 60-Minute Lesson

PP Dimension	Item	Key question	Score
Intellectual quality	Higher order thinking	Are higher order thinking and critical analysis occurring?	0
	Deep knowledge	Does the lesson cover operational fields in any depth detail or level of specificity?	2
	Deep understanding	Do the work and response of the students provide evidence of understanding concepts and ideas?	2
	Substantive conversation	Does the classroom talk break out of the initiation/response/evaluation pattern and lead to sustained dialogue between students, and between students and teachers?	2
	Knowledge as problematic	Are students critiquing and second guessing texts, ideas, and problematic knowledge?	1
	Metalanguage	Are aspects *of* language, grammar and technical vocabulary being foregrounded?	0
Relevance	Knowledge integration	Does the lesson range across diverse fields, disciplines and paradigms?	2
	Background knowledge	Is there an attempt to connect with students' background knowledge?	1
	Connectedness to the world	Do lessons and assigned work have any resemblance or connection to real life contexts?	4
	Problem based curriculum	Is there a focus on identifying and solving intellectual and/or real world problems?	1
Supportive school envt	Student control	Do students have any say in the pace, direction or outcome of the lesson?	0
	Social support	Is the classroom a socially supportive, positive environment?	3
	Engagement	Are students engaged and on-task?	4
	Explicit criteria	Are criteria for student performance made explicit?	3
	Self-regulation	Is the direction of students' behaviour implicit and self-regulatory?	4
Recognition of difference	Cultural knowledges	Are diverse knowledges brought into play?	0
	Inclusivity	Are deliberate attempts made to increase participation of all students from different backgrounds?	2
	Group identity	Does teaching build a sense of community and identity?	2
	Citizenship	Are attempts made to foster active citizenship?	0

Conclusion

This case illustrates how on the surface even an interesting, engaging, student-centred lesson which integrates ICT well does not necessarily result in deepened mathematical understandings. Often another question from the teacher would have helped the student to make links between understandings. Similarly, more critical appraisal of the software being used, asking oneself, "What will the students gain from completing this activity?" Of course, it is to be expected that novice teachers will refine their skills over time with continued critical reflection on practice and ongoing professional development. Nonetheless, it is useful for teacher educators to choose snippets of classroom practice and to use them as discussion starters to draw out opportunities for richer teaching and learning episodes which focus on discipline-specific language and understandings in the future. Authors of this study are keen to develop the PP framework into an observation tool for viewing snippets of classroom practice to emphasise that student engagement alone will not necessarily lead to deepened mathematical understandings.

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