A Secondary Mathematics Teacher Explains his Non-Use of Computers in Teaching

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This study uses qualitative research methods to examine why a senior secondary teacher who was experienced in teaching mathematics and using computers would not use either generic software such as spreadsheets, or exploratory software (e.g. *Maths Helper*) in his teaching of mathematics. The teachers' beliefs about the nature of secondary mathematics, the nature of teaching, his own teaching practice and assessment issues underpinned his rejection of the use of computers in the classroom.

Internationally, there has been considerable support for the use of computers in mathematics teaching and learning (Gentile, Clements, & Battista, 1994; Kaput, & Roschelle, 1997). A number of authors have argued that teachers' beliefs about mathematics and learning are critical in making decisions as to the use of computers in their mathematics teaching (e.g., Henry & Clements, 1999; Sarama, Clements & Henry, 1998; Thompson & Thompson, 1996). Other researchers have linked teachers' preferred pedagogy with willingness to use computers (Ernest, 1992; Galbraith & Chant, 1990; Neyland, 1996; Sarama et al., 1998). The importance of assessment procedures in influencing teachers' practices has been recognised (Barnes, Clarke & Stephens, 1996; Becker, 1994). More specifically, assessment has been reported to have an effect upon teachers' use of computers and graphics calculators (Croft, 1998; Tobin, Routisky, & Jones, 1999). This paper explores the reasons why one senior secondary teacher does not use computers to teach secondary mathematics. It examines the importance of the teacher's beliefs in determining his responses to the use of computers, particularly exploratory software such as *Maths Helper* (Vaughan, 1997).

Theoretical Framework

Norton (1999) has described two orientations to the use of computers in mathematics teaching and learning. The first is *calculational* where computers are primarily seen as instruments to carry out procedures for deriving results (e.g., calculating numerical result or quickly graphing data). The second is *conceptual* where computers are used to build conceptual understandings by focusing students' thoughts upon the underlying mathematical ideas and relationships between these ideas.

Ernest (1996) provided a useful framework for describing beliefs about the nature of mathematics. His framework has two opposing poles, the poles being represented by *absolutist* and *fallibilist* beliefs. Ernest contended that teachers with absolutist beliefs were likely to view mathematics as objective, absolute, certain, incorrigible and based on deductive logic. Thus, such teachers would see mathematics as fixed, logical, inhuman and objective. By contrast, teachers with a fallibilist view of mathematics were likely to see mathematics as the outcome of a social process and, according to Ernest, see mathematics as open to revision. He contended that teachers with fallibilist beliefs frequently had a pedagogy associated with person-centred and humanistic approaches to teaching.

Kuhs and Ball (1986) identified four different teaching approaches. The first is *content-focused (performance),* where the emphasis is on student performance (this has also been described as instrumental (Skemp, 1978; Thompson, Phillip, Thompson, & Boyd, 1994). The second category is *content-focused (understanding),* which is similar to content-focused but with an emphasis on understanding the ideas and processes rather than performance. The third category is *classroom-focused*, where the main concern is that classroom activity be well structured and organised according to effective teacher behaviours. The final category is *learner-focused*, which is an approach consistent with constructivist theories of teaching and learning, namely where the learner is engaged in exploring and formulating ideas and actively constructing their own knowledge from the environment (Lucking, 1999). The latter approach also recognises the importance of social interactions (Cobb, Yackel, & Wood, 1992).

Method

The study was a qualitative educational case study (Stenhouse, 1990) involving a hermeneutic approach (Denzin & Lincoln, 1994). The design of the study and the analysis of the data heeded the criteria for the constructivist inquiry of Guba and Lincoln (1989). Techniques such as member checking, peer review, triangulation of multiple data sources, testing of developing assertions on emerging and previously collected data, and actively seeking negative instances, were used to enhance the trustworthiness and authenticity of the data.

Subject and Context

The teacher, (pseudonym Peter), was very experienced having been a teacher of mathematics for 23 years. He was highly computer literate and was responsible for overseeing the school administration computing resources, including programming and networking. Yet he did not use computers in his mathematics teaching.

Peter had extensive experience in software that has been used in mathematics education such as spreadsheets, LOGO, function plotters and statistics software. In addition he had used Structured Query Language to construct data base shells for the school, constructed the school web page and set up spreadsheet templates for analysing the school sports results. His formal qualifications included a Bachelor of Science degree, a Diploma of Education (a post-graduate preservice teaching award), a Graduate Diploma in Education (Computer Education) (an inservice award in computer education) and a Master of Information and Technology degree. He taught both computing and mathematics in his technology-rich suburban secondary school at the time of the study - information processing and technology (IPT) to Years 11 and 12 students and mathematics to Years 10 and 12. He stated that personal lack of expertise in using computers was not important at all in influencing his use of computers in his teaching. After acknowledging that the school was technology rich, he stated that, "if he wished to, he could use computers quite extensively in his teaching of mathematics".

*Data Gathering M*ethods

Data was gathered using the following procedures and instruments:

- structured interviews, that explored Peter's experience, beliefs about the potential of computers in teaching mathematics, beliefs about secondary mathematics, and beliefs about teaching and learning and specific pedagogical practices
- lesson observations
- artefacts collection (students' workbooks, assessment items, Peter's web site publications on student learning.)
- member-checking interviews (Guba & Lincoln, 1989).

The first author volunteered to teach two of Peter's classes with the exploratory mathematics software *Maths Helper*. The first author introduced Peter to the software and showed him lesson plans that the first author had prepared to teach the algebra concepts that Peter's classes were about to study. *Maths Helper* contains mathematics tools that enable students to explore mathematics concepts and engage in mathematical modelling; for example, a line tool that can be placed on any curve to give the linear function of the tangent at that point, a maximum and minimum tool, an angle tool that gives readings in degrees and radians, a point tool, and an intersection tool. In addition, the software can calculate values and display them in tabular form, plot and calculate derivatives, plot integrals, normals, and lines of best fit for most functions that students encounter in secondary mathematics, and also determine correlation coefficients. The software can be used conceptually since it allows students to use the tools above to explore mathematical concepts, particularly algebra and calculus concepts.

Results

The results are presented as assertions. Excerpts of Peter's "voice" are presented as supporting evidence.

Assertion 1

Peter used computers rarely in his teaching of mathematics because he saw their potential as calculational and he believed that they did not facilitate student conceptualisation. Peter reported that using computers in mathematics teaching was "less effective than traditional methods in developing higher order thinking". However, he argued that they could be used to "do more complex situations where large numbers were involved" and "for crunching numbers". He stated, "I have not seen software that enhances students' mathematical thinking skills".

Assertion 2

Peter's beliefs about the nature of secondary mathematics were absolutist in nature. He believed that student use of the exploratory software such as *Maths Helper* was not necessary. He stated that school mathematics was essentially absolute since "virtually all (mathematics) done at school level is well developed... it would be a rare occurrence for a student to develop any new mathematics". Further, he had a low evaluation of students attempting to model in secondary school, "Mathematics modelling done in secondary school is fabricated, artificial and simplified ... (because) students are nowhere near the level (mathematically), which is needed to look at real life situations." He stated that secondary mathematics courses were for preparing students for tertiary mathematics by developing the concepts and skills that could be built upon at a university level, so that students could begin to explore real models there. He added that the reason school mathematics should be treated with certainty "was because of the limited sophistication of thought of adolescence". Peter commented that using software such as *Maths Helper* to help students explore mathematical ideas "could waste time trying to rediscover things" that he "could explain quickly and besides they might get the wrong idea". In short such activities, "were not necessary for the development of basic skills and knowledge". It should be noted that most of Peter's post teacher training study was related to Information and Technology study rather than mathematics education.

Assertion 3

Peter believed that computers were not useful in the explaining mathematics concepts to students nor in illustrating examples of mathematics procedures. He claimed that teacher explanation and student practice of procedure was the most effective way to teach mathematics.

I would be extremely explicit and I would be explaining things, the knowledge is coming from me so I believe that I am explaining it. I am a great believer in example, learning by example, learning skills and you actually learn skills from examples. Obviously it needs prerequisite knowledge and if you know the prerequisite knowledge you can just extend, extend slightly for people's area (of comfort) to be covering a new concept, then the students will be happy.

Peter's explanations gave insight into his image of teaching as well as his role as a teacher. He stated that students "should be able to perform basic skills and have the theoretical background to use numerical methods with understanding". The statements above support the conclusion that Peter had a content-focused (performance) orientation towards teaching (Kuhs & Ball, 1986). In aiming to achieve this goal he rejected learner-focused approaches since he believed that students would be like him and "much rather have an expert to help me quickly than spend hours trying to work out a solution for myself". He believed that software, including the exploratory software *Maths Helper,* could not aid in this process. As he explained, "I don't think it (computer technology) should be a substitute for theoretical approaches". Lesson observations showed that his practices supported his statements - he taught by example and explanation.

Peter compared the learning of mathematics to music learning. He said mathematics was "like a performance and, as in music, learning required that the student practise until the task could be done fast and faultlessly". He stated: "I believe it is important to drill, in that here is a need for doing the same thing so many times it becomes second nature". On his school web site, he noted:

Teachers often convey information to the full student group orally, with perhaps the aid of visual cues. Teachers often give instructions and explanations using this technique because it can be a very efficient and economic way of communicating with a group of students. Listening should occur while performing no other tasks, apart perhaps, from taking notes on what is being communicated. It is imperative that all students listen to the teacher when required. Students need to practise their mathematics even after they have had initially had success at a task, just like a musician practises a tune after she as learnt it.

Assertion 4

Peter's beliefs about assessment supported his non-use of computers. Peter believed that assessment should be in the form of tests or examinations and this strongly influenced his teaching. For example, he stated: "Assessment is the determining factor of what we are on about and my teaching is actually geared towards assessment ... we have to get students to jump through those hoops". His view of assessment had implications for his use of computer technology:

Well, like it or not, I believe that there is in Queensland, at the moment, a test called the QCS (Queensland Core Skills) (Computers are not part of the QCS assessment). So students have to become competent at pen and paper work, without a doubt that is the way to go if you are not going to disadvantage people. If I wanted I could actually quite easily spend a lot of time using computer technology. (However) I think I'd be doing the wrong thing by them ... I don't use computers much because of the syllabus, and the outcomes that are needed by students to succeed on a long-term basis in our society ... I don't think I have seen software which enhances the vast majority of students' knowledge and skills, that are required by out syllabus or assessed.

In short, Peter's interpretation of the syllabus assessment criteria supported his non-use of computers in his mathematics teaching. In actual fact, the syllabus recommended an "investigative" approach to teaching and learning and encouraged the use of computers in mathematics learning (Board of Senior Secondary School Studies, 1992). Peter would not use learner-focused and computer orientated approaches nor would he allow the first researcher to model this teaching with his classes because he not believe that such approaches would not be as effective as his own teaching in helping students pass assessment tasks.

Conclusions and Implications

Peter had an essentially calculational orientation in relation to the potential of computers in secondary mathematics learning. He did not believe that computer use (including spreadsheets and exploratory software) could compete with his existing teaching strategies in developing students' abilities to do and understand mathematics. His reasons for not using computers in his teaching of mathematics related to his beliefs about the nature of secondary mathematics, teaching, learning and assessment.

Peter's image of secondary mathematics was absolutist in nature in that it consisted of well-established facts and procedures that students needed to learn and practise. Thus, the potential of exploratory software (such as *Maths Helper*) which could empower students to construct mathematical knowledge, particularly by modelling mathematical concepts and phenomena, was largely irrelevant to Peter. In fact he stated that using such software could waste valuable time, which could be better used listening to the explanations of an expert and by practising demonstrated skills.

Peter's image of teaching and learning was primarily one of transmission where mathematical skills and knowledge are transmitted from the teacher to the learner (Atweh & Cooper, 1995; Perry, Howard, & Tracey, 1999). His understanding of constructivist learning theory appeared confused in that he appeared not to distinguish between student construction of new mathematical knowledge and student construction of their own understandings of mathematical knowledge that had been stipulated in the mathematics syllabus. His understandings of constructivist theory may have been one reason why he preferred a transmission approach to teaching. Peter's instrumental teaching orientation of content-focused (understanding) (Kuhs & Ball, 1986) was consistent with his beliefs about teaching and learning. His perceptions of the nature of teaching and learning mathematics may well have influenced his perceptions in relation to the potential of software to help students understand mathematics. Finally, Peter's interpretation of the syllabus assessment criteria served to support his existing beliefs and practices. In summary, Peter did not believe it was in the best interest of his students to require them to use software, particularly exploratory software, in their learning of mathematics.

This case study illustrates that beliefs about the nature of secondary mathematics, teaching and learning and interpretations of assessment requirements can act to reinforce each other to create strong resistance to the use of computers in mathematics teaching. The implications for the professional development of teachers are that attempts to encourage teachers like Peter to consider the potential of using software to teach mathematics needs to be multi-dimensional and consider teachers' existing beliefs and practices. That is, if reformers wish teachers like Peter to use computers in their teaching, it needs to be shown that the use of software such as *Maths Helper* could help students to conceptualise mathematical abstractions more effectively and efficiently than traditional practices.

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