

Teaching Mathematics Using the Internet

Esther Loong

University of South Australia
<LOOEY001@students.unisa.edu.au>

Bruce White

University of South Australia
<Bruce.white@unisa.edu.au>

This paper examines teachers' use of the Internet in the teaching and learning of Mathematics. The study draws upon data collected via an online survey and interviews with six teachers. It reports on their beliefs, strategies for use and their perceptions on how it impacts on students and their learning of mathematics. Some comparisons are made between the ways teachers used the Internet.

Internet access and hence access to World Wide Web (WWW) is now commonplace in schools in Australia, for example all public schools in South Australia have an Internet connection as a result of the DECSTech2001 project (DECS, 2002). As with any new innovation in schools there is a need to evaluate its impact and since the late 1990's there have been calls to research the ways the World Wide Web is changing classroom practice and student learning in general (Windschitl, 1998) as well as study the effectiveness of Internet resources for mathematics at all year levels (McCoy, 1996). It has been reported (Herring, 1999) that schools in the developed countries are still at a fairly early stage in fully exploiting the Internet for teaching and learning in general and that this is particularly true in the area of mathematics (Becker, 1999). Mathematics teachers were reported by Becker (1991) as having lower measures of Internet use and perceived value compared to every other group.

This paper reports on interviews conducted with six teachers who have used the Internet to teach mathematics. These teachers were identified as a result of their responses to an online survey, conducted by one of the authors. The survey results show that 79% of the teachers surveyed use the Internet to teach mathematics and that even those who reported that they have never used the Internet to teach Mathematics would like to use it. Why the interviewed teachers chose to use the Internet and the impacts these choices have on their teaching and their students' learning is the focus of this paper.

The Role of the Mathematics Teacher in a Web-Based Environment

Although critics of the use of the Internet in education such as Selwyn (1998) claim that the Internet gives the learner complete control and makes the teacher virtually redundant save for suggesting possible routes of enquiry, this is not necessarily the case. For example, in a case study with a small group of grade 8 mathematics students collecting data from the Internet, Gerber and Shuell (1998) stressed that attention should be given to instruction on how to search for information on the Internet and that adequate preparation of students in terms of content knowledge and critical thinking skills is necessary to foster deep appreciation for its use in mathematics. Far from being redundant, Idris (1999) found that the mathematics teacher is not merely a 'straight forward facilitator' but a 'learning partner' and 'collaborator in the educational process'. Moor and Zazkis's (2000) study with a group 36 elementary preservice teachers navigating a predetermined Web site found that students have concerns regarding the lack of teacher support in general, as well as when learning

mathematics. Clearly, the teacher's role in the use of the Internet is one of significant importance and not to be taken lightly.

Mathematics teachers' resistance to the use of computers in the classroom have been found to be related to their beliefs about mathematics teaching and learning and their existing pedagogies, the increasing number of topics to be covered in the mathematics curricula, their perceptions about examinations, assessment problems, concerns about time constraints, preferences for particular text resources and lack of technical support (Norton, 2000). This is consistent with the findings of Becker (1999) that pedagogical beliefs and practices were strongly related to how relevant teachers see the Internet for their teaching and whether they use it.

Impact of Web-Based Instruction on Students

There are a number of aspects to Web-based instruction that have been identified, enhancing mathematical thinking (Idris, 1999), enjoyment & motivation (Moor & Zazkis, 2000) and self-concept among females (Goudelock, 1999). Additionally, Web-based communications present unique opportunities for students to display and develop inquiry processes as well as an appreciation of other cultures and view points (English & Cudmore, 2000), encourage creativity in looking for solutions (Nagai, Okabe, Nagata, & Akahori, 2000) and enhance students' ability to articulate and explain with the opportunity to build on others' ideas (Sherin, Mendez, & Louis, 2000).

Interaction and Mathematical Learning

The Web has resources of varying levels of interactivity and functionalities that can be exploited by teachers to teach mathematics (Loong, Barnes, & White 2002, Loong 2001). The different strategies teachers typically use in a mathematics classroom can be further enhanced or replaced with the use of web objects that are available on the Web (see Barnes & Loong, 2003). Several levels and taxonomies of interactivity have been proposed (eg. Jonassen, 1988; Schwier & Misanchuk, 1993; Sims, 1997). Sim's engagement-control model (Sim, 1997) focuses on instructional, graphic and communication design which enables the interactions to motivate and engage the learner. It proposes three dimensions for interactive instruction. Firstly, engagement which is either navigational: where the user moves from one location in the application to another; or instructional: where the user is involved with the content in a way designed to facilitate learning. Secondly, control which refers to the extent to which the system or user is making the instructional or navigational decisions. The third dimension, interactive concept provides an indication of the type of interaction that might be expected under the varying conditions defined by the model.

Sims (1997) is of the opinion that 'interaction is intrinsic to successful, effective instructional practice as well as individual discovery' and that the level of interactivity in multimedia facilitates the acquisition or development of new skills and understanding. Results from some of the case studies conducted with interactive dynamic and static construction environments such as Cabri Geometry and Geometers' Sketchpad, Geometric Supposer, and Logo-based environments (see Asp & McCrae, 2000; Glass & Deckert, 2001) help students focus on the relevant aspects of diagrams, promote higher levels of understanding between and among properties of diagrams, help students form conjectures

and formal reasoning as well as furnish rich experiences for validation of such conjectures. Other interactive programs like Derive (see Lehtinen & Repo, 1996) enabled systematic manipulation of a function and its representation and students were found to achieve higher levels of conceptual understanding and greater permanence in algorithmic procedures.

Method

The use of the Internet in the teaching and learning of mathematics as indicated in the rationale is in its infancy. In situations such as this it is common to use a qualitative approach (Denzin & Lincoln, 2000). The study seeks to gain insights into teachers practice in this area through the use of semi - structured interviews. This study has used a two stage data collection process. In the first stage an online survey was conducted using a convenience sample of Mathematics teachers. The intention of this survey was in part to identify teachers who were using Information and Communications Technologies (ICT's) and in particular the World Wide Web (WWW) in their teaching of Mathematics. The review of literature in the area had indicated that the use of the Internet in the teaching of mathematics was not widespread and so location of suitable teachers to interview would need to be targeted. The intention of the study was to examine teacher practice when using the WWW and so convenience sampling was considered to be an appropriate approach. The survey data was then analysed and a number of teachers were then selected on the basis of their responses. The teachers selected, had identified themselves as being regular users of ICT in general and the WWW in particular when teaching mathematics.

These teachers were then involved in the second stage; they were interviewed using a semi-structured interview. The interviews were then transcribed and analysed to look for common themes that emerged from the data. The researchers examined the data independently in order to develop more reliable themes. The six mathematics teachers came from a range of settings, 3 from city non-government schools in Adelaide, 2 from country government schools in South Australia and 1 from a country government school in Victoria.

Results and Discussion

Teacher and Student Web Uses

All of the teachers mentioned the use of the WWW for their own research and how they used a variety of materials from the WWW within their own teaching. The teachers all indicated that they were confident and regular users of the Internet and three of them mentioned that they used it on a daily basis.

Interactive Web Materials. The most common use of the WWW that the all of the teachers mentioned was its use for student research and they commented on the ease of access, and the variety of information available. All of the teachers also mentioned the use of mathematics specific materials available via the WWW, for example, a statistics course, online calculators and simulations, interactive applets, past year exam questions and solutions.

The value of these materials were extolled by some teachers as being able to do things far better than they would have been able to otherwise and also save them having to physically

make them. The level of interaction of some of the materials was mentioned by all of the teachers in a very positive sense. The ability to interact with the materials was highlighted in a number of different ways, which supports the work of Sims (1997). An example given by one teacher was

To actually unwrap the solid and show the net and then wrap it up and then show all these different 3-dimensional shapes like in wire models. You can have them as wire models or you can have them as the original whatever they were and the kids love that 'cos they saw lots and lots of shapes that they normally wouldn't see in real life. And I can remember a couple of them saying to me they thought that was great. You know they could really see where they couldn't have been able to see before.

While another saw great potential in the way manipulation of the web objects have on the visualisation of concepts.

It's one site where you can have a scatter plot and you can physically move the line from negative to positive correlation and from no correlation right through to negative one right through to positive one and you can basically see the little dots and crosses on the page, like on the screen when it is coming into alignment it's positive one and then moving out of the path and then as you go right around it goes right through to minus one? So it is really good, a really quick visual illustration of correlation

The ability to quickly access a variety of quality materials was considered to be very important

you know you can reinforce a concept or you can get into a topic, or you're halfway through a topic and you want to have a change and so you go on and you do a crossword, or a maths puzzle on there or you look at a concept like that. So, that's the two things initially I'll be focusing on.

With one of the teachers indicating that the materials on the web were far superior to the textbook materials.

Communications on the Web. The teachers expressed differing views about getting students to use the communication features on the Internet. One teacher felt that as students get better in their use of the e-mail, having e-pals with people from other countries make the communications more meaningful.

My class have e-pals in Denmark and in America and I correspond with those people twice a week. ... the students are reasonable in their use of computer, getting better in their use of e-mail. Having an e-pal have meant they tend to waste less time sending pointless e-mail to people who are living close by and now sending e-mail to people overseas

However, another teacher felt that student forums where answers and solutions are given in response to questions are posted might not be as helpful to the students as perceived to be.

It depends on how it's done. I can see a lot of ways of getting your homework done without understanding it – it has a problem there – but if you gave a challenging question from a year 9 to a university student, they would give you an off-the-cuff solution that would be trivial to them, and they probably wouldn't spend the time discussing the process by which that was arrived at, and I think as such the students are only getting the right answer they're not actually learning, so if you were going to communicate with somebody, it needs to be someone at your level or someone who is at least trained or interested in, in communicating with you at your level

Another teacher saw the value of student forums as possible extension activities for students, however he warns of the dangers lurking in such communications

we've made that available to students in 7 and 8, because teachers are also saying 'What do we do with these kids that are talented? We don't have the resources, we don't know how to extend them', and I've said 'Here's a site. When the students actually finish their work they can go to that site and there are questions ... I would be very wary about the nature of it – I would be reticent to open that,

it's a can of worms to open up. We're having quite a few problems with damage to computers and with viruses and hacking and all that sort of stuff. I think there are a lot of security problems. I don't use it because it's a novelty. It still needs to be used under a fair degree of supervision and direction

Impacts on students. All of the participants talked about increased motivation of their students to do Mathematics. Four of the teachers commented on the use of data off the web gave the data a context and made it seem more authentic. For example one teacher said,

It motivated them to do statistics more. I'm not sure whether it changed how well they understood a column graph, but I think it made them more inclined to do the statistics, and I guess it does make them ... I mean I could have given them the data, and I could have told them the story, but they wouldn't have believed me. It would have been 'Oh yeah, here's the maths but you're making up stuff', but because it came from the internet it had that authenticity, dubious though it may be. They believe that it's on there, therefore it's real.

While another had similar views and said 'Whereas off the web you can get stuff that is far more real. There are a lot very interesting data sets that you can access and use, work on functions, work where it's applied to real situations that is not feasible in a lot of textbooks anyway.' The use of online calculators that are made available by banks also proved to be a useful means of adding authenticity to the tasks set. One teacher recalled

there's a typical example I'm thinking of is the finance simulator kids are going to look for visas as they are going through the web site and clicking on links , they find a finance simulator where you know they put in , might put in a ten thousand dollar loan , um, they are thinking of a car they might want to buy, in year 11 typically and they plug it in and they see this graph come up, you know an exponential sort of decay graph and they see how long it takes to pay off the car, and they say 'Gee that's a long time,' and they get an idea of how much money they paying off in the end, so you know they start to ask questions about that

Factors affecting teacher use. There were two main factors that the teachers commented on time and reliability. The teachers all mentioned time as a factor in their planning to use the Internet in their teaching. Two elements were consistently mentioned; using the Internet is time consuming and there was not always time available in the computer rooms when you needed them. The time consuming aspect was often mentioned in conjunction with the amount of work to be completed as a result of a full syllabus and that this was more a senior years issue.

Now I went to the Internet and got some designs off there and showed them those. I was thinking about taking them to a website and letting them do some work there, but I decided that in the interests of productivity, it was actually easier and I thought better, for me to take what I wanted off the internet and deliver it in a different format because, let's face it, the ultimate enemy of these sort of introductory activities is time. You can't afford to take them down for two lessons if you only get out of it 15 minutes worth of material that is really necessary. It would probably be with the junior classes around about once a term, and with the senior classes, years 11 and 12, it would either be never or frequently, depending on if you are going to do a ... Like last year I had a year 11 class and I used the prototype of this website every day for four weeks. Apart from that I didn't use it with any year 11 or 12 class, so in another words it's a feast or a famine. You either use it as a substantial part of your teaching – or this is the way I've done it anyway – or you don't use it at all, because you don't have time to pop in there and spend a lesson doing this.

The increase in time required was often offset in the teachers' comments that the topic is better understood, because of the motivational aspect and interaction aspects of the WWW use. They used this a means of justifying the extra time. 'I don't think they're picking up the mathematics any quicker, but they understand why we're doing the mathematics. They understand how to interpret their results better because they understand the context better,

and that's a benefit.' However often the tension was still there 'The web certainly doesn't shorten that time. It enhances but it also has the potential to waste' The other factor that was highlighted by the teachers was the reliability of the system. 'I don't think I've ever used it for a whole class on the web at one time, completely because of lack of access and at times the degree of reliability.'

Teacher beliefs. A very consistent message from the teachers indicated that they believed that if students are enjoying and are engaged in what they are learning they tend to learn at a faster rate for example one teacher said 'The main thing in teaching is that if kids really enjoy what they're doing, they'll learn at the most phenomenal rate you can imagine ... I will do anything to keep kids interested in mathematics.' This teacher's use of the Internet was extensive and included e-mailing solutions to questions students ask on a regular basis, using web material to keep students in (detention) occupied.

The approaches given by the teachers to achieve this interest and engagement varied slightly but there was a consistent message related to making the mathematics real. An example of this was one teacher who said 'Whenever possible, I think students should be involved in the whole process of problem-solving, and that includes the gathering of data and the background research, and the planning that goes into that, and if I take that away and make it all neat and clean and ready to go, I take away a really valid part of the mathematics, and make their experience the poorer for it.' While another focussed on the application aspect.

I mean there is still an element of traditional algorithmic-based maths teaching, but I think application is an important part of stuff, of genuine problem-solving, and I think that is something that has become more of a focus for me recently, and that's the reason why the Internet becomes more useful to me in recent years, is because application is a more bigger part of my lessons, rather than just make sure the kids can do the questions in the textbook. I'm interested in what can they do, and let's see how this applies.

Conclusion

The WWW has the potential to be a significant resource in mathematics education. The variety and interactive nature of the materials available can make mathematics "real" and enable students to visualise mathematical concepts in ways that were previously not easily achieved. It is an under utilised resource but there are some teachers who are beginning to explore the possibilities and so it is important that these explorations are investigated in order to make the best use to enhance students understanding of mathematics.

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