Using Web-Based Mathematical Interactive Exercises and Exploratory Investigations: The Possibilities and Pitfalls

Esther Yook-Kin Loong
Deakin University
<esther.loong@deakin.edu.au>

This case study looks at how a teacher used interactive exercises and exploratory investigations to reinforce concepts that have been learnt in a Year 8 Mathematics class. It highlights the practical problems faced by the teacher in terms of technical issues such as slow download times and logging on problems as well as class management issues. The findings are discussed in the light of the teacher's mediation with the affordances of the Internet.

Although there have been descriptions of secondary Mathematics teachers' strategies with the Internet (e.g., Gerber and Shuell, 1998; Idris, 1999; Goudelock, 1999; Moor & Zazkis, 2000; Loong, 2003), literature on the use of the Internet by Mathematics teachers in unguided non-experimental classroom situations is few and far between. There is limited information about Web-based pedagogies for teaching secondary school Mathematics, still less about effective ones. However, several efforts have been made to identify the mathematical resources that are available on the Web (e.g., Michener, 1997; Kissane, 2001; Herrera, 2001; Loong, 2001) and to match these to Mathematics curriculum (Barnes & Loong, 2003). Professional development for teachers in this area mostly directs staff to suitable sites but there is little discussion about what constitutes good practice or effective Web-based pedagogy. This is true of the use of the Internet in Science as well. Student teachers have claimed that the lack of effective pedagogy and a shortage of role models that demonstrate successful use of the Internet are barriers to the development of effective Internet use in Science (Twidle, Sorensen, Child, Godwin & Dussarte, 2006). There is hence a need to disseminate how Mathematics teachers manage relevant usage of Web objects in particular Mathematics topics to help move the uptake forward. This paper presents a case study with the intent of sharing effective Web-based pedagogy and role modelling that will help beginning teachers, and teachers new to the idea of using the Internet in Mathematics education, see the possibilities and pitfalls associated with Internet use.

Findings from research (Becker, 1999; Vanfossen, 2001) indicate that teachers have not harnessed the potential of the Internet in significant ways and this is true of all grades and subject areas. Although most social studies teachers (who have used the Internet for "low-order" information gathering) indicated that they would like to use more of the Internet for their teaching, most claim a lack of practical, hands-on training on its classroom use is a major barrier to its use (Vanfossen, 2001).

In trying to make sense of why Internet use is limited in scope and substance, Wallace (2004) presented a highly plausible framework for understanding teaching with the Internet. Based on case studies of three Science teachers using the Internet in the classroom, she argued how the five affordances of boundaries, authority, stability, pedagogical context and disciplinary context interact with fundamental challenges of teaching to produce variations in Internet use. The word 'affordances' was explained as possibilities for what the technology can do. The lack of boundaries in the Internet, for example, can offer either exciting possibilities or problems for the teacher. This is compounded by the issue of establishing the authority of material gleaned from the Internet and ensuring students have the ability and skills to do so. Teachers would have to either establish "authoritative sites" or create norms whereby students learn to be critical consumers of Web information. Although the fluid mutability of Web materials means that Internet information is up-to-date, instability can also create pedagogical problems for the teacher as it is difficult to predict what will happen when students open or follow a link. While pedagogical context is easier to monitor with other resources such as text books, it is rather elusive on the Internet as it is a challenge for the teacher to keep track of what students do online unless constraints are put on the Internet–based assignment. Finally, resources on the Internet are usually not placed in any particular framework or sequence that follows teachers' curricular needs. This results in teachers having to work that sequence into a disciplinary framework for its use to be effective.

In this paper, discussions will revolve around whether these affordances were present and how they have been brought to play in the teaching of Mathematics with the Internet.

Background to the Study

This case study is drawn from observations of nine Mathematics lessons in a Year 8 class at Blue Lake High School (pseudonym). Blue Lake High School is a large, comprehensive high school with students joining the school at Year 8. Students come from neighbouring suburbs where most of the residents come from the middle income group. All students undertake a common Mathematics course in Year 8. However, students experiencing difficulty may be offered a modified course that is more appropriate to their needs and abilities. Other students are in ability groupings studying mathematical concepts which allow them to progress through to the next stage. Movement between classes was possible at all times because the content was consistent, but taught with varying degrees of depth. The Year 8 students who participated in this study followed a modified program. The number of students for this class was registered as 18 but there were usually about 13 to 15 students in any one session due to students either being sick or away for some personal reasons or participating in some official activity.

Peter (pseudonym), the teacher who taught this class, was a very experienced Science teacher who had been asked to teach Mathematics. In a preliminary survey on Internet use conducted by the author, he mentioned that he used the Internet at least once a week (although he considers himself a "novice" in terms of Internet competency) and had used the Internet more for his teaching of Science than for Mathematics. Although he had about 40 hours of professional development in the use of Information and Communication Technology (ICT) he had none on the use of the Internet. Due to his own perceived lack of knowledge on the use of the Internet to teach Mathematics (he answered in the survey that the constraint he faced was his 'own lack of skill in this area'), Peter volunteered to be part of this project despite acknowledging in the survey that he faced constraints such as limited booking times and limited student access to computers and the Internet.

As a result of the flexibility afforded in a modified program, Peter was able to embark on a series of Web-based lessons that engaged the class for several weeks and covered different topic areas such as fractions, algebraic expressions, decimals and coordinate geometry. In each of these lessons he prepared an instruction sheet which detailed the Web page students had to go to, what they had to do and questions which had to be answered. Most of what he initially did focussed on worked examples which required a lot of reading by the students but which he eventually changed when he found that students were not on task. With some suggestions from the author he incorporated some interactive exercises and some interactive exploratory investigations into the later lessons.

Method

Data for this case study was obtained through a mixed methods approach where semi-structured interviews were conducted with the teacher as well as with students and a quantitative survey was administered to students. All conversations were audio taped with interviewees' consent and later transcribed. Participant observation was used in the classroom with the author taking the role as "participant-as-observer" (Dane, 1990). Classroom observations entailed observing Peter's classroom management, the Web objects and strategies used and students' reception to this mode of learning in terms of academic learning time (Berliner, 1987) with the Internet-based learning task. Classroom interactions were documented via written notes by the author and short semi-structured interviews were carried out at the end of each lesson with Peter. This was to clarify what was observed as well as to give Peter an opportunity to reflect on the lesson. A survey on attitudes towards Mathematics and the use of the Internet was administered to all students involved after the series of Internet based lessons. This instrument consisted of a number of questions taken from the Fennema-Sherman Mathematics Attitudes Scales (Mulhern & Rae, 1998) and some questions on the Internet developed by the author. These additional questions had a Cronbach alpha internal consistency reliability of 0.9238.

Findings and Interpretation

This section describes the findings and interpretations of the case study. It includes issues such as the practical difficulties faced by the teachers, time on task and classroom organisation, the value of teacher checks and the progress made by students with the interactive Web objects.

Practical Difficulties

Class observations during online sessions showed that there were problems that were technical in nature. A considerable amount of time was lost waiting for the site to open up. This slow download was especially evident when everyone logged in at the same time. In one lesson, one student had difficulty logging on and didn't start until about 20 minutes later. Another student had difficulty getting into the Web site, so she copied the questions off one of the other students instead and tried to answer the questions herself. In another lesson, one particular student was not able to get the image to open up spontaneously in one computer. He was told by a peer to right-click on the image icon which then enabled the image to be opened. Peter had to go around the classroom trouble shooting but eventually all the students were able to access the page and work on it. This took up most of the time for that lesson. In another session some applets did not download easily because the Shockwave player was not installed resulting in students not being able to do any Web-based activity that day. Peter had to resort to using the traditional method of teaching with the whiteboard. Other difficulties were of a different nature and included students running out of credits to work on the computer and having to work on an alternative task. The other difficulty that arose was the reading ability of the students and their typing skills. A major problem here was that some uniform resource locaters (URLs) were very long, for example, "http://www.sosmath.com/algebra/fraction/frac3/frac3.html" and many students made mistakes in keying them in. This resulted in students taking a long time just to log onto the sites (approximately 10 minutes).

Where technical preparation such as ensuring the right programs are installed and log-on access such as passwords are involved, it is good practice for teachers to check this prior to the lesson. As with any technology use, trial runs should be carried out with the Web sites concerned to ensure they load properly and that applets are loading easily and can be opened. Some contingency or alternative Web objects should be planned as back-ups in the event a particular Web-object fails to load. Where addresses are long, the sites could be pre-loaded on the school Intranet, or e-mails sent to students with the URL as a hyperlink. Such approaches would save the time and frustration of typing long and wrong addresses. If laptops are to be used, the batteries should be checked to ensure that they are fully charged before they are used. Technical problems will and do happen even to the best teachers and the sharing of these among faculty will help pre-empt more of them from occurring. By restricting students' work on the Web to predetermined links, some of the problems associated with the "boundlessness" and the "instability" of the Internet observed by Wallace (2004) were thwarted. In predetermining the links, the teacher knew what activities were in those Web pages and could be certain they were functioning - two factors crucial to the implementation of the Internet-based strategies. However, this case study also highlights that success with Internet work is not dependent only on the aforesaid factors but importantly on the reliability of the technology. This unreliability of the technology, as Cuban, Kirkpatrick, & Peck (2001) observed, is one of the reasons why teachers often revert back to conventional practices.

Time on Task and Classroom Organization

In the early Web-based lessons began, which were in the form of worked examples that students had to read and then try the exercises, time on task was observed to be rather minimal. The class was chaotic with students chatting among themselves, checking e-mail, not being able to log on because they had forgotten their passwords and waiting for a long time for the Web page to load into the computer. However, time on task increased as the lessons progressed. In the first lesson the total time on the Internet task was approximately 15 minutes in a 40 minute lesson (37.5%). In the second lesson time spent on the Internet was approximately 20 minutes in a 50 minutes lesson (40%). By then Peter had realised that the worked examples required too much reading and students were not motivated. He began to utilise some of the Web objects suggested by the author. The third Internet lesson time on Internet was approximately 40 minutes in a 90 minutes lesson (44%). Subsequent lessons were all more than 50% time on task. Peter had also set up a routine where he would check that they knew which part of the instruction sheet they were to work on before he let them into the room. He also asked them to mark the Websites that they had gone into as "Favourites". By the seventh lesson most of them were able to log on quietly and do their work accordingly.

Having a routine helps students to move into whatever task they had to do faster than when there was none. In this case having the worksheets and getting some of the sites that were to be used at a later time marked as "Favourites" helped set the disciplinary context for a better organised Web-based Mathematics class. Resources on the Internet are usually not placed in any particular framework or sequence that follows teachers' curricular needs. Teachers have to work that sequence into a disciplinary framework for its use to be effective (Wallace, 2004).

The Value of Teacher Checks

To ensure proper monitoring of student progress, teacher checks are essential. Peter explained the necessity for such a system.

I keep track by incorporating teacher checks at various points where I think they're needed and, for example, if some of the applets have interactive activities that the students have to complete, the dilemma with them is that they then have to clear the screen and go onto another one, so I have also included things where the students, when I do the teacher checks, if it requires an on-screen response, I then have to sight the completed screen, and therefore keep a check on it that way. Alternatively I ask them to record in their exercise books particular things. It might mean if they've drawn a graph … let's suppose the applets, for example, in drawing a graph for a weight was 3x+2 or something, the applet of the last site that I was at simply requires the students to put in the slope and the y-intercepts – the 3 and the 2, and instantly it would draw the graph for the students. I then ask the students to draw the graph, copy the graph as it was on the screen, on paper, so that's a second way. The third way is to get the students to record directly on the worksheet that I've designed. That might mean putting the coordinates of a particular point on paper, or recording some way anyway, directly onto the worksheet, and then I do a teacher check after that.

When interactive Web objects are used and screens are constantly changing, having a teacher check in place means that monitoring of student progress is more systematic and informative to the teacher. Students' perceptions of teacher checks are varied. While some find it frustrating to have to wait for the teacher to check before proceeding, others see value in getting some form of feedback of their current work.

Yeah, it just becomes annoying sometimes because you've got to wait for him to come. (Jayden)

... it's good that he has it because ... you can just like check your work I guess, and then... do it, so yeah, I think that's good. (Calvin)

Teacher checks are important forms of feedback to the teacher about where the students are at and help keep students on track. As Wallace (2004) observed, pedagogical context on the Internet is rather elusive. It is much easier to monitor the work of students when working with other resources than when they are online. Unless tasks are constrained by designated links and work from the screen is sighted, it is a challenge for teachers to know where students are at in their search for knowledge on the Internet. Under these circumstances, presetting the boundaries enables students to focus on the Mathematics concept to be learnt although in other disciplines like literacy there have been calls to allow for less structured and less 'sanitized' forms of exploration (Burnett & Wilkinson, 2005).

Progress Made with the Interactive Web Lessons

Peter's comments on the lesson were revealing and confirmatory of the progress that these students were making with the interactive Web objects.

Certainly with the graphing exercises, they worked better than yesterday's lesson which was a normal classroom lesson. . . .We were doing exercises out of a book, graphing exercises, they had to create a data table from some information and convert that into graph, so they had found that pretty difficult but today they didn't have to create a data table but they did get the concept of the relationship between the y and the algebraic expression which I thought was an important plus for today's work. I don't think they would have got that necessarily from doing their work yesterday. So I think putting the two together the two approaches is a useful way to go. The Web site we used today had a different approach, much more mathematical approach which we didn't have.

One of the students, John, said he really liked doing this on the Internet and one could see he was very keen to get on with his exercises.

It will tell you . . . you're too high . . . you've got to go down a bit more, and it tells you you're too below or like somewhere around that area you can pick it. Yes its easier, so you know what you're doing . . . you don't have to keep asking the teacher . . . it's there if you like need it, you have to go back and review it if you keep getting it wrong, and if you want to see where you went wrong.

These comments seem to lend credence to Year 8 students' general perception of the use of the Internet in this form. Table 1 shows student perceptions on the use of worked examples and interactive exercises on the Internet.

Table 1
The Use of Worked Examples and Interactive Exercises on the Internet

Items	Percentage response					Mean	sd
	SD	D	U	A	S A		
I understand better when I did the interactive Mathematics activities on the Internet	6.9	10.3	10.3	31.0	41.4	3.90	1.26
Learning Mathematics with the Internet helps me learn Mathematics faster	3.4	6.9	24.1	31.0	34.5	3.86	1.09
I would like to do some of the Internet Mathematics activities in my free time	31.0	24.1	20.7	17.2	6.9	2.45	1.30
I would like my teacher to e-mail me interesting Internet Mathematics activities to work on	31.0	31.0	17.2	13.8	3.4	2.28	1.16
I like the quick feedback I get with the interactive exercises	3.4	3.4	17.2	62.1	13.8	3.79	0.86
I feel comfortable doing the exercises on the Internet	0.0	3.4	0.0	51.7	44.8	4.38	0.68
I feel stressed answering the questions on the Internet	31.0	55.2	3.4	3.4	6.9	2.00	1.07
The feedback I get from the Internet exercise is not helpful	31.0	37.9	17.2	10.3	3.4	2.17	1.10
Doing the questions on the Internet is more fun than doing from the textbooks	0.0	0.0	6.9	31.0	62.1	4.55	0.63

Note. N=29, SD= Strongly Disagree, D=Disagree, U= Undecided, A= Agree, SA= Strongly Agree, sd= standard deviation

These responses were taken from two classes of Year 8 students from two public schools, one of which is Blue Lake High School. Generally students agreed that they can understand better when they did the interactive Mathematics activity with 41.4 % strongly agreeing. There was general assent among this group of students to the use of the Internet to learn Mathematics. The nature of the activities carried out in this case study was interactive and animated in form. These activities were consistent with the activities implied in the survey. There was a general consensus among these students that they benefited from doing the interactive activities on the Internet. There was overwhelming (93.1%) agreement that doing the questions on the Internet is more fun than doing them from the textbook. As many as 75.9 % of them liked the quick feedback they receive while doing the exercises whereas 72.4 % felt they understood better when they did the interactive activities on the Internet. Over one half the students (65.5%) felt they learned Mathematics faster while learning on the Internet. The majority (96.5%) felt comfortable doing the exercises on the Internet. Although there was positive response to the use of the Internet in the classroom for learning Mathematics, the response to doing extra work on the Internet was not as positive. When asked if they would like to do some of the Internet Mathematics activities in their free time, less than half (44.9%) agree. Similarly, when asked whether they would like their teacher to e-mail them interesting Mathematics activities to work on, 62% disagreed. There was a significant correlation between math comfort and wanting their teacher to e-mail them math activities to work on (Pearson's $r = 0.445$, $p=.016$, $N=29$).This has implications for the teacher to extend students who are comfortable doing Mathematics by using the Internet. Interview sessions with some of the students revealed that they disagreed because they did not want to work when it was time to relax. It infringed on their recreation time. However some students answered that they might like to do it so that they can get better at Mathematics. These findings suggest that the interactive exercises and worked examples have motivational value and enable students to understand the concepts better.

John's Story

When observations began it was noticed that John wasn't particularly good at the basic facts of Mathematics and seemed to show a disinterest in the lesson. In the first two lessons he chatted with his friends most of the time. When he was asked he said that he didn't like Mathematics and didn't do well in it. His book work was often incomplete and devoid of much of the work that should have been done by this group of students. As the Internet lessons progressed he became more on task and was able to complete most of the work given. In the graphing activity, he was very adept at doing the first exercise and got both Web pages of problems all correct. He moved on to do the second part which was "Graphing a Line (y=mx+b)". This was amazing considering he said at the start of the observations that he didn't like Mathematics and didn't do well in it anyway. He also said during the seventh Internet lesson that that was the first time he'd ever finished something in Mathematics. He seemed pleased when Peter told him he would give a few more merits because of his work that day. When asked how he liked Mathematics now, he said 'It hasn't got very far, but now it's pretty easy'. He also shared that if he had Internet access at home he would like to do some of these activities so that he could "get better at it, come back to school and get better marks and stuff." John's story points to the possibilities the Internet has to increase the motivation to learn Mathematics. If only teachers can persist long enough for students to get over the initial hiccups of using the Internet to stay on task, the Internet certainly holds promise of alternative pedagogy.

Concluding Comments

Getting students to stay on task while on the Internet is certainly no small task. It requires effort in preparation, close monitoring in the classroom to avoid disciplinary problems, overcoming technical glitches and a huge amount of confidence that these problems can be resolved with perseverance and routine. While it was necessary and easier for teachers to have a framework of mathematical resources available, teachers' knowledge and discernment when choosing suitable interactive objects are even more crucial to the success of this strategy. A Web–based interactive task that is just reading worked examples and clicking on answers might not be as effective as tasks that present powerful visuals for concept development or allow for student manipulation of variables to see the changes. These resources have been categorised as interactive animated and non-animated investigations in the Web typology by Loong (2001). The two affordances of boundaries and authority (Wallace, 2004) were not obvious in this case study because the boundaries have been preset by the teacher when the URLs were given and authority of the material presented had already been established by the teacher as well as the author. However, having a selection of relevant Web objects that is still active on the Web for each related topic gave Peter the stability, disciplinary and pedagogical context to use the Internet in a way that allowed students to engage in their learning.

References

Barnes, A. & Loong, E.Y.K. (2003). Teaching Mathematics and the Web: A task-object approach. In Goos, M. & Spencer, T (Eds.) *Mathematics~Making waves*. Proceedings of the 19th Biennial Conference of the Australian Association of Mathematics Teachers, 13-17 January 2003.

Becker, H. J. (1999). *Internet use by teachers*. The Center for Research on Information Technology and Organizations (CRITO), University of California, Irvine. Retrieved October 22 2001, from http://www.crito.uci.edu/TLC/FINDINGS/Internet-use/startpage.htm

Berliner, D. C. (1987). Simple views of effective teaching and a simple theory of classroom instruction. In Berliner, D. C. &. Rosenshine B. V (Eds.), *Talks to teachers* (pp.93-110). New York: Random House.

Burnett, C. & Wilkinson, J. (2005) Holy lemons! Learning from children's uses of the Internet in out-of-school contexts. *Literacy*, pp.158-165

Cuban, L., Kirkpatrick, H., & Peck, C. (2001). High access and low use of technologies in high school classrooms: Explaining an apparent paradox. *American Educational Research Journal, 38*(4), 813-834.

Dane, F. C. (1990). *Research methods*. Belmont: Wadsworth, Inc.

Gerber, S., & Shuell, T. J. (1998). Using the Internet to learn Mathematics. *Journal of Computers in Mathematics and Science teaching, 17*(2/3), 113-132.

Goudelock, C. P. (1999). *Effect of the use of an Internet-based 'problem of the week' on high school geometry students' problem-solving achievement and attitudes towards Mathematics.* Unpublished EdD thesis, Montana State University.

Herrera, T. A. (2001). A valid role for the Internet. *The Australian Mathematics Teacher, 57*(1), 24-27.

Idris, N. (1999). *Use of the Internet for improving teaching and learning in Mathematics*. Proceedings of the International Conference & Exhibition on Education Superhighway 1999, Regional Centre for Education in Science and Mathematics, Penang, Malaysia.

Kissane, B. (2001). *The Internet and Mathematics education*. Retrieved December 16, 2003, from http://wwwstaff.murdoch.edu.au/~kissane/Internet.htm

Loong, E.Y.K. (2001) Web Mathematics Anyone? *International Education Journal*, *2*(4), 2001, Educational Research Conference 2001 Special Issue.

Loong, E.Y.K. (2003) Using the World Wide Web to teach Mathematics in secondary school: Some examples, *The Australian Mathematics Teacher*, *59* (1), 23-28.

Michener, N. (1997). *Implications of the use of the Internet in the teaching and learning of school Mathematics*. Retrieved October 16, 2002, from http://www2.tpg.com.au/users/michener/title.html

Moor, J., & Zazkis, R. (2000). Learning Mathematics in a virtual classroom: Reflection on experiment. *Journal of Computers in Mathematics and Science Teaching*, *19*(2), 89-113.

Mulhern, F., & Rae, G. (1998). Development of a shortened form of the Fennema-Sherman Mathematics Attitudes Scales. Educational & Psychological Measurement, 58(2), 295.

Twidle, J., Sorensen, P., Child, A., Godwin, J. & Dussart, M. (2006). Issues, challenges and needs of student Science teachers in using the Internet as a tool for teaching. *Technology, Pedagogy and Education, 15*, (2), 207–221

Vanfossen, P. J. (2001). Degree of Internet/WWW use and barriers to use among secondary social studies teachers. *International Journal of Instructional Media, 28*(1), 57.

Wallace, R. M. (2004). A framework for understanding teaching with the Internet. *American Educational Research Journal, 41*(2), 447-488.