Web-based Mathematics: Student Perspectives

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This paper presents the results of a survey conducted with students (N=97) whose teachers have used the Web in their mathematics classes. The survey looked at students' attitudes towards learning mathematics and their responses to the use of the Internet for learning mathematics. Factor analyses were used to determine the constructs that underlie the survey. Indices formed were used to explore their relationships with each other and with other variables. Interview findings were able to support and lend insight into some of these results.

This paper draws on the findings of a survey and interviews conducted with students after class observations in Stage 2 of a completed PhD study. Four teachers and their classes were observed when the students worked on Web-based online tasks set by the teacher. This paper presents the results of the survey, which focus on their responses to the use of the Internet for learning mathematics. Factor analyses was used to determine the constructs that underlie the survey. In an attempt to provide a transparent view of the constructs, indices were then developed with the simple sums of variables. Interview findings were able to support and lend insight into some of these results.

Distinguishing Between the Internet and the World Wide Web (or Web)

The Internet is a vast collection of inter-connected networks that are connected using the *TCP/IP* protocols. These protocols or languages support email (SMTP), instant messaging, the World Wide Web (HTTP and HTML), news groups and file transfers (FTP). The Web is thus only a part of the Internet albeit an enormous part. Web documents called web pages are linked to one another via hyperlinks and can contain text, graphics, sounds and videos. Web 2.0 is an improved version of the Web as it allows for collaboration using file formats that allow for interaction whereas in the original Web file formats were not interactive. However, using small Java programs (called 'Applets') and JavaScript, both programming languages, static Web pages can include functions such as animations, calculators, and other fancy tricks. Clearly there are differences between the Web and the Internet but in this paper they have been used interchangeably except where the context suggests otherwise.

Theoretical Framework

Student Engagement in Mathematics

In countries where mathematics is not a compulsory subject after a certain age, the number of students choosing to continue mathematics to advanced levels has been decreasing. In Australia, there have been reports (e.g., Thomas, 2000) that the number of high school students studying advanced mathematical courses continues to decline and that this has been a consistent trend since 1990. There are many reasons why students drop out but various studies have shown that it is often because of the feelings of helplessness and anxiety induced during mathematics learning (Reys, 1998; Buxton, 1981; Tobias & Weissbrod, 1980;). This has to do with students' perception of mathematics and the way

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mathematics is taught (Miller & Mitchell, 1994). Teachers need to present or set tasks that allow mathematical understanding and engagement to take place (Flewelling & Higginson, 2001; Fennema & Romberg, 1999) The use of workbook mathematics has also been cautioned against (Romberg & Kaput, 1999; Ollerton, 1999) as it has little value in connecting students' learning of ideas to the real world and tends to isolate mathematics from its uses and from other disciplines. Research (e.g. Hollingsworth, 2003) has shown that in practice the teaching methodology commonly used is still one of demonstration and practice and teacher talk. At the forefront of the argument for change is that of student motivation. The concept of student motivation lies not just in the affective (emotional) aspects such as enjoyment of a particular activity but also in the high quality cognitive engagements in students' activity (Evans, 1991). Can the World Wide Web with its myriad of resources and communication functionalities engage students mathematically and how?

Efficacy of Web-based Mathematics

The Internet as a tool has not been largely exploited for mathematics (see Goos & Bennison, 2008; Barnes & DETE, 2002; Becker, 1999). There are few studies on student uses of the Internet for mathematics and those reported (e.g. Moor and Zazkis, 2000; Gerber and Shuell, 1998; Goudelock, 1999) found students benefitted from the freedom to choose their own pathways but that this need to be scaffolded by teacher direction. While hypermedia-based systems with its affordances of multiple perspectives, collaborative learning, learner-orientation and interdisciplinary learning, have been found to have positive effects on students achievements over traditional instructions (Liao, 1998), teachers should be aware of the advantages and disadvantages this can bring to the similarly hypermedia- based environment of the Web (Liaw, 2001). These disadvantages include learner's background discrepancy, disorientation, over-rich information and ineffective user-interface. Interactive Java applets in the Web often seen as learning objects have been extolled as enhancing the online learning experience (Gadanidis, 2001; Mawata, 1998) but research into learning objects have also shown that students are well aware of what makes for a 'good' or 'bad' learning object and its efficacy for learning (Mussprat & Freebody, 2007).

Interactivity, multiple perspectives and access to rich information in itself is insufficient to engage students. Teachers need to know what makes students engage in a particular activity on the Web if they are ever to use it effectively. It is within this framework of engagement in learning and the role Web functionalities can play in enhancing engagement that this paper is written. This paper seeks to discuss in what ways the Web hold the answer to student engagement in mathematics. How do students view the use of this technology in learning mathematics? Deciphering the response of students who use different types of online materials for their learning will help to determine these materials' motivational value in promoting student engagement.

Methodology

A total of 97 students from three schools in South Australia participated in the study. These students range from Year 8 to Year 12. Table 1 details the compositions of the school settings, the classes and the pedagogical approaches taken.

Table 1

A Summary of the Composition of Classes, School Settings and Pedagogical Approaches

Type of School	Year level	No. of Students	Pedagogical Approach taken with the Web based lessons
Blue Lake High School (Pb)	8	13	Interaction with worked examples, interactive objects and interactive exercises
Longview High School (Pv)	8	16	Interaction with interactive objects and interactive exercises
Blue Lake High School (Pb)	10	12	Information search on Pythagoras theorem
Turnside Grammar School (Pv)	11	16	Directed investigation on loans and repayments
Blue Lake High School (Pb)	12	30	Data search for a Statistic Project
Turnside Grammar School (Pv)	12	10	Data search for a Statistic Project

Note: Pb= Public; Pv =Private

A survey was administered to the students (n = 97) after their teachers have used the Web in their mathematics classroom to determine students' attitude and perceptions towards mathematics and the use of the Web for mathematics learning. The mathematics attitude scales were derived from the Fennema-Sherman Mathematics Attitudes Scales (FSMAS) whilst the Internet items were researcher generated. Factor analysis was conducted separately for mathematics attitude items (16 items) and the Internet items (10 items). In this paper, analyses and discussion address findings relating only to Internet items.

Findings and discussion

Students' Response to the Use of the Internet for Learning Mathematics

Cronbach alpha internal reliability for ten items pertaining to students' perceptions of the use of the Internet in mathematics education was 0.9238. A Principal Component factor analysis was conducted on these items for all years (n = 97). Oblimin with Kaiser Normalization extracted two factors with eigenvalues equal to or greater than 1. The KMO value was 0.903 and Bartlett's Test of Sphericity was high (678.253) and significant. All variables had MSA above the acceptable level of 0.5. The first factor seems to relate to students' evaluation of the Internet as a tool for learning mathematics and was thus labelled as 'Valuation of the Internet as a tool for learning mathematics'. The second factor seems to relate to students' emotive response when the Internet is being used and was labelled as 'Emotive response to the Internet'. The first factor accounts for 60% of the variance and the second factor 11.5%. Table 2 gives summary information about the factor variables, recoded items and the alpha values. From the factor analysis, simple tallies of the component were obtained by adding all the variable values in the component to form new indices.

Table 2
Summary about Internet Variables

Construct: Valuation of the Internet as a tool for learning mathematics
Learning mathematics with the Internet helps me learn mathematics faster.
I understand mathematics concept better when my teacher uses the Internet to teach.
I wish my teacher would use the Internet to teach mathematics.
I enjoy learning mathematics with the Internet.
I dislike it when my teacher uses the Internet to teach mathematics.*
I think the Internet is very useful for learning.
I don't think it is a good idea to use the Internet in class.*
Cronbach's alpha = 0.9362
Construct: Emotive response to the Internet
I feel nervous when we use the Internet in mathematics *
Feel frustrated when we use the Internet to learn mathematics *
There are lots of interesting materials on the Internet
Cronbach's alpha = 0.7333

Note: * indicates recoded items

To have an idea of what is meant by a low or high level of the construct, tallies based on the scales used in the instrument and the numbers of variables in the factors were computed. This produced a range of indices that reflect to a certain extent the level of agreement as in the original scales. Table 3 shows the range of indices for the new construct 'Valuation of the Internet' and the percentages of students in those ranges. The inter-quartile values obtained from the frequency statistics table show that the first quartile falls within 20 points of the index, the second quartile within 24 points and the third quartile within 28 points of the index. Similar to the Valuation of the Internet construct, the Emotive construct indices were grouped so that they reflect the original scales.

Table 3
Range of Indices for Valuation of the Internet and Students' Response

	Index range obtained	All SD or D	All D or U	All U or A		All A or SA
Valuation of the Internet	7-35	7-14	15-20	21-27		28-35
% of students		8.2	19.6	43.3		28.9
		Associated Inter-quartile ranges				
		≤ 20		20.5 - 24	24.5-28	>28
Percentiles		0-25%		26-50%	75%	100%

The results showed that about 30 % of the students seem to be either agreeing or strongly agreeing that the Internet has value as a tool for learning mathematics but the majority seems to have a moderate valuation of the Internet. A moderate valuation could suggest uncertainty about the value of the Internet. There could be two reasons why this is so. Firstly, it could suggest that students have not used the Internet sufficiently to be able to make a judgment about its value. There might be a perception that until one has used the Internet in a variety of ways and with sufficient frequency; the value of the Internet is still difficult to decide. The second reason could be that students may find it difficult to decide because its value may differ according to the way it had been used or according to the subject matter in which it was used. The Internet might have been useful with certain topics but not in others; similarly the way in which the Internet has been integrated by their teachers may have been successful in some lessons but not in others. Hence there is indecision about its value. The results show that about 62% of the students seem to have a high emotive response towards the Internet indicating that students are generally well disposed to the use of the Internet in mathematics and are comfortable with it. The following section will discuss the perception of students from different year levels.

Year Differences in Internet Variables

Table 4 shows significances of the independent samples T tests of means on each of the constructs (i.e. 'Valuation of Internet' and 'Emotive Response to the Internet'). The constructs 'Valuation of Internet' and 'Emotive Response to the Internet' show that Year 8 students are distinctly different in their attitudes to the Internet to the other years. For example, there is a significant difference in the mean valuation of the Internet between Years 8 and 11 at p=.001 with Year 8 mean being higher than Year 11 (as indicated by bold typeface). These findings seem to suggest that the Year 8 students value the use of the Internet more highly than older students. This difference seems to be even more pronounced with older students.

Table 4
Significance of Independent Samples t-tests of Means between Year Levels for Different Constructs

	Levels of significance between difference of means of year levels					
	8-10	8-11	8-12	10-11	10-12	11-12
Valuation of Internet	**0.011**	**0.001**	**0.000**	0.925	**0.683**	**0.495**
Emotive Response to the Internet	**0.048**	**0.052**	**0.000**	0.872	**0.957**	**0.786**

Note: All significances two-tailed with equal variances not assumed. **Bold** indicates the first year measure is greater than the second year measure.

Four possible effects may cause this. The first is that the Internet is a novelty for these Year 8 students who are younger and are still enamoured by the prospect of doing mathematics with a learning tool like the Internet. Older students have probably become used to using the Internet for their studies and so it does not hold much value for them. If novelty effects of the Internet are the cause for the higher valuation of the Internet among the Year 8 students then similar results should have been obtained also for the Year 10 students as interviews with Year 10 students found that many at this year level were also not using a lot of the Internet in their mathematics. However, the results showed that there were no significant differences between Year 10 students and Year 11 and 12 students. This means a second effect is possibly at work, which is the specific pedagogical approach used by the teacher. That being the case, it might be instructive to re-examine the different strategies used for each of the year levels and the different Web resources used.

The approach and type of Web material that the Year 8 teachers employed with their students is different from that used by the teachers for Years 10, 11 and 12. Year 8 students used interactive learning objects, which enabled them to manipulate variables. The students were able to control the learning objects at will. These activities were usually carried out in tandem with teaching done in the classroom. The visuals aided in concept development and reinforcement. Students who have used the interactive learning objects have this to say.

> I think it's very creative, and I think it can make lots of people interested in Mathematics...Because it shows you, like you can understand it better because it's coloured and...it explains to you what you have to do and then it just gives you an example. So show you the difference, like to show you how much it is, like on a bar graph, like 40 is less than 50, so it will be less than halfway. (Allan, Y8, Pb)

Doing searches for mathematical proofs and theorems can be both interesting and daunting. It was interesting because the presentations of the proofs were animated and visual but not necessarily easily understood by some.

> Proofs ? I didn't really understand them …. Yeah it did *a bit* like you could see how the triangles move shape and they go into each other, yeah it made it more clear … (Lennie Y10, Pb)

> It's just a lot easier for me to understand and a lot easier to get information from the internet than looking in books. … Well, they've got different diagrams for different things and stuff and it just pops up information little by little and helps you understand. (Nathan Y10, Pb)

It was daunting in that one had to go through and decide which one to choose to read because of the amount of information.

> There are heaps of things on Pythagoras, there's like 20 thousand odd pages on it … (Lennie Y10, Pb)

Although the approach taken by teachers of Year 10, 11 and 12 students were Web-based, the approach was one of information search and utilizing the richness and authenticity of such information to enhance the perception of mathematics and its application to real life. Although the wealth of information and easy accessibility to a myriad of true–life references was welcomed by the students when they did the projects, many felt that not much mathematics was learnt from such assignments of information retrieval and data collection.

> Probably not the understanding of it because it's there for you, you just … you don't really have to use any brain power, but yeah, I guess understanding through doing the whole assignment, I don't know whether that's due to the internet or not. I wouldn't say it was. (Jenna Y11, Pv).

> In this assignment? No, not really. I knew how to do everything. It's just data, you're just reading, not doing mathematics. Yeah, there wasn't mathematics in it. (Margaret ,Y 12 Pb).

> … it didn't really teach me any additional mathematic skills. It was more that collaboration of data and all that analysis and stuff were things that I had already learnt in class. I didn't really learn much more from the Internet. (Jane Y12, Pv).

Despite the fact that Year 12 students are older and may perhaps be better able to handle the huge information overload, some still have reservations about accessing data from online databases and websites. When asked what was one thing they did not like about doing this project using the Internet one student said it was '…probably the fact that there was so much data to sort through and that probably took a lot of time?' This brings to mind what Liaw (2001) cautioned against with regards to the over-rich information and disorientation.

It cannot be concluded here that the findings about students' valuation of the Internet and their emotive responses to the Internet are a direct result of the teaching strategies described in the case studies. The valuations and emotive responses of these students towards the Internet could be due to a third reason and that is the effect of their experience and engagements with the Internet in other disciplines. These experiences might include exposure to and usage of the Internet in disciplines such as Society and Environment, and English. It could also be due to different teaching and learning approaches at other year levels. Internet access at home may also contribute to a favourable emotive response to the Internet. To study which of these influences play a role in these responses would need a classic experimental control study and is outside the scope of this project.

A fourth reason for the differences in valuation of the Internet and the emotive responses between Year 8 and Year 11 and 12 students could be that as students move up to higher levels where assessments and year-end examinations become more important (particularly in Year 12), assessment related mathematics seem more pressing and relevant than exploration of mathematics concepts. These students may not see value in using the Internet in class unless it is directly related to assessments. Whatever the relative influences of these effects may be there is a clear distinction in the valuation and emotive response to the Internet between the Year 8 students and the Year 11 & 12 students. Future studies could take this investigation further.

Conclusion

There are limitations to the generalisability of the findings in this paper partly due to the small number of students involved as well as the uncontrolled conditions in which the case studies have been undertaken. However as an alternative resource for teaching mathematics, these findings do point to the potential of the Internet to motivate students. Interactive web objects that animate or can be virtually manipulated, and provide feedback to students seem to engage and motivate students better than Web pages of data or information. However animations and the interactive nature of a Web object does not necessary guarantee learning and comprehension among students. Teachers will still have to use their pedagogical content knowledge to determine how a certain interactive object could promote engagement and understanding. It is hence instructive for teachers to know that students want'… learning objects (LOs) that allow interaction with the LO, that allow more control over how to progress through the LO, that do not look like conventional classroom activities, and that are more game-like …' (Muspratt & Freebody, 2007).

It was surprising that despite the good intentions of the teachers to incorporate real-life scenarios and real data into the mathematics lessons, these have not translated into an appreciation for the use of mathematics in everyday life for the students. For many, the data and information retrieved were just perceived as numbers to be inserted into tables and had no real life relevance. The 'messiness' of real data had not been highlighted and exploited. This has implications for teachers and teacher educators. It may be that to truly harness the potential of the Web for mathematics we need to we step out of the 'clean' confines of school mathematics and engage students in numeracy where mathematical, contextual and strategic know-how (Hogan, 2000) are essential. This is where the interdisciplinary learning and richness of tasks that is afforded by the Web can take place.

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