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Web-based conferencing: Pedagogical asset or constraint? [1]

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Educators are increasingly engaging in innovative practices which use the World Wide Web as a pedagogical tool. One aspect of Web usage which shows promise of enhancing learning is that of Web-based conferencing. This paper describes an intervention in which the authors used a Web-based conferencing tool to promote dialogue within an international community of mathematics educators and prospective school teachers on the nature of mathematics and mathematics learning. Results of the intervention suggested that while benefits of new understandings about mathematics, improved writing, and collaboration did occur, affective outcomes of using a web based tool were often negative. The need to critically assess the pedagogical benefits of web based conferencing, both cognitive and affective, is discussed, and implications for practice are outlined.

Introduction

As we approach the third millennium, the use of new communication technologies is becoming pervasive in many areas of education. Students in both elementary and secondary schools now routinely search the World Wide Web for information to be used in class projects; university courses are being offered where all contact with tutors is by electronic means, including online conferencing and email; and 'virtual universities', which have no physically located campus, are being established (Carty, Stark, van der Zwan and Whitsed, 1996; Duckett, Painter, Gay, Gerson, Moore and Wallet, 1995). The Web is used by many as an information resource and as a way of encouraging communication across distance.

However, concerns have arisen about too readily embracing the technology without carefully researching the implications. Some academics feel that the literature thus far has stopped short of asking critical questions about the relationship between Web technology and

pedagogy; that most studies merely describe what was done with the technology, rather than focus on cognitive and affective student learning outcomes (Windschitl, 1998). Mergendoller (1996) suggests that we need to examine the relationship between technology, pedagogy and student learning.

This paper focuses on one aspect of Web usage in learning: computer-mediated conferencing. The theoretical framework for this paper is placed within the social constructivist discourse. The research literature in this area indicates that computer-mediated conferencing tools are especially well-suited for providing social arrangements that enable collaborative construction of knowledge (Blanton, Moorman, and Trathen, 1998). In their social constructivist review of research in this area, Blanton et al suggest that such tools provide opportunities for prospective teachers to participate in a discourse that encourages the integration of everyday practice in the classroom and theoretical knowledge. Bonk, Appleman and Hay (1996), in describing how computer conferencing has increased the range of viewpoints available to students, suggest that we investigate how such "tools encourage learners to explore and accommodate alternative viewpoints". Others (Windschitl, 1998) consider the complementary aspect of computer-mediated conferencing: the production of material, by students, **for** others. Windschitl cites research that states that there are significant positive benefits in writing for others, both with email and more conventional forms of composition. He asks what effects occur when students compose material for publication on the Web (p.31).

Another aspect of Web-based conferencing which requires examination in a social constructivist framework is that of collaborative learning, whereby collaboration "engages students in the construction of shared meaning" (Blumenfeld, Marx, Soloway and Krajcik, 1996, p.39). A number of researchers have reported on the advantages of Web-based conferencing where students have collaborated in learning tasks. Sherman (1995) describes the gains in students' critical thinking when they have to post regular reflections at a conferencing site, then react to their colleague students' postings. Eklund and Eklund (1997, p.18) report how collaborative work on the Web tended to break down the division between 'expert' and 'novice' computer users, and also helped "demystify the cyber-jargon".

Windschitl (1998, p.30) raises the question of whether 'communities of learners evolve' when students collaborate in learning projects on the

Web. Shulman, quoted in Sherin, Mendez and Louis (1997), cites four pedagogical principles which help to foster a community of learners: *activity* where the learner actively participates in the discussion; *reflection* where the learner reflects on and analyses his or her own thinking; *collaboration* in which the learners support each other's learning; and *community*, where a class is seen not as just a collection of individuals, but as a learning community. Studies by Carty et al. (1996), Eklund & Eklund (1997), Blumenfeld et al. (1996) suggest that not only does Web-based conferencing have features which allow these principles to be implemented, but, because of the Internet's world-wide reach, it also permits the broadening of a learning community to one of international scope.

A number of drawbacks to Web-based conferencing have been outlined by some researchers. Owston (1997, p.29) draws attention to effects of problems with computer hardware and reliable access to the Web, particularly in the early stages of a program. These problems can lead to "a downward spiral in the calibre of discussion". There is also some evidence that computer-mediated conferencing has limitations in sustaining dialogue momentum through several rounds of responses (Farquhar, McGinty, & Kotcho, 1996). Another drawback referred to by both Owston (1997) and Carty et al. (1996) is the (often hidden) cost of development of Web-based programs - usually a much greater cost, particularly in terms of the time spent by the developers, than that of more traditional modes of delivery. McWilliam (1997, p.6) expresses a different concern: that there may be a "sense of the loss of intensity in pedagogical encounters" in the absence of face-to-face contact when "virtual pedagogies" are employed.

In the area of mathematics education, a topic which lends itself well to discussion by prospective primary school teachers is their beliefs about the nature of mathematics and mathematics teaching and learning. A strong body of literature in mathematics education points to the fact that many prospective primary school teachers perceive mathematics in very restricted, instrumentalist terms - see, for example Mayers (1994), Burton (1996), and Crawford and Deer (1993). Instead of approaching mathematics as a creative endeavour with cultural and social relevance, many prospective primary school teachers see it as a rule-based set of procedures which is learnt most effectively by rote. The present authors saw a need for their students to "challenge their own views of mathematics so that they become open to visions of mathematics as a

dynamic, creative and problem solving discipline in which procedural methods are merely means to ends rather than the ends in themselves" (Schuck and Foley, 1998).

While the research study as a whole investigated an intervention with the aim of challenging beliefs of prospective primary teachers, this paper considers one aspect of the study, namely the potential of a Web-based conferencing tool to enhance learning about the nature of mathematics, and mathematics learning and teaching. The Web-based tool was used both as an information conduit, and as a way of promoting communication within an international mathematics education community. In particular, the pedagogical potential of Web-based conferencing for exploring alternative viewpoints, writing for a Web community, and promoting collaborative learning was investigated. Details of the intervention are outlined, and the results are discussed.

The study

The investigation was a case study in the interpretivist tradition, of the use of Web-based conferencing to challenge the beliefs of prospective primary school teachers, in a mathematics education subject. The conferencing tool was TopClass [2], a Web-based application which could be used by any student with access to the World Wide Web. The conferencing tool was used as the vehicle through which ideas could be exchanged in a learning community. The intervention took place in the second semester of 1997 in the subject Mathematics Education 1, taken by prospective teachers (henceforth also referred to as 'students') in the first year of their Bachelor of Education at an Australian university.

The intervention

In the first lecture, students were asked to write personal responses to two focus statements which would form the basis for the computer conference. The statements were:

> *On the nature of mathematics*
> "I'd describe maths as the calculation of certain things to do with numbers, and the use of certain formulas and methods, simplifying, counting and subtracting and things like that." (Maria, first year prospective primary schoolteacher)
>
> *On the cultural context of mathematics*
> "Mathematics is universal, objective and unchanging. It is independent of social, cultural and political values." (Compilation of prospective teachers' comments)

The first statement was made by a student in a previous research study carried out by one of the authors, and the second was a compilation of comments made by a number of prospective teachers in the same study (Schuck, 1996).

Students were introduced to the TopClass conferencing tool in the campus computing laboratories by the authors/subject developers. They gained further familiarity with TopClass in an information technology subject being taken during the semester. The students were required to form groups of five or six, and respond to one of the above statements; their responses being based on their personal reading from the categories below and from their subsequent discussion within the group. The available reading material offered a wide range of views about the nature of mathematics. This material fell into three categories:

- Links to relevant material from the Web provided by the subject developers on the discussion site.
- Responses to the focus statements from respected mathematics educators who had been invited to make contributions by the subject developers - also placed on the discussion site. These mathematics educators were from a number of countries including Australia, Fiji, New Zealand and the United Kingdom.
- Readings from journal articles, which were placed in the library's special reserve.

A limit of 500 words was placed on each group's response in an endeavour to ensure the production of a reasonably concise and coherent piece of writing, which would then be posted by the students into the discussion site of TopClass. About midway through the semester, after each group had posted its response, students were required to read all the student responses to their chosen focus statement, and, in the same groups as before, formulate a second response to the statement which took into account the views expressed by the other groups. The mathematics educators who initially responded to the focus statements also had the opportunity to contribute to the continuing discussion on the Web.

The two postings by each group were graded and formed part of the subject assessment. The authors/subject developers read both sets of responses and used the TopClass electronic mail facility to send grades with comments to each group.

Methodology of the research study

The participants

One hundred and sixty five prospective teachers participated in the study, of whom one hundred and forty were female and twenty five were male; one hundred and one students were eighteen to twenty years of age and the rest twenty one to forty seven years of age; fifty one had been in full time employment before entering the course; about two-thirds lived in middle to high socio-economic areas of Sydney.

Data collection

Three instruments were used in the collection of data.

1. *Pre- and post-intervention surveys*. Prior to the intervention, students were required to fill out a survey anonymously. It included questions probing students' beliefs on the nature of mathematics and mathematics learning, attitudes to computer conferencing, and views on the usefulness of the Internet and computers in learning. Students scored forty-one items on a five point Likert scale, ranging from 1 'strongly disagree' to 5 'strongly agree'. The questions on the technology aspect from the survey can be seen in Table 3 in the Results section. For more details of the part of the survey dealing with challenging beliefs, see Schuck and Foley, 1998. A post-intervention survey was also completed by the students. It included the same questions as the first survey, adjusted for tense where necessary. Students were asked to supply code names so that the data for individual students from the two surveys could be matched.

2. *Reflective journals*. Students were also required to maintain a reflective journal throughout the semester. Students' entries included thoughts about the collaborative process of the Web-based discussion; their experiences with the computer hardware and software; and their reflections about the nature of mathematics, starting with their initial reaction to the two focus statements. At the end of the semester, the authors collected the journals and gained permission from students to use them as data in this study.

3. *Open-ended questions*. The post-intervention survey also included five open-ended questions about the Web-based discussion, and the use of computers and the Internet. These questions were included to gather further information and to permit triangulation of the data through cross-checking of the data from the other sources. Examples of open-

ended questions were: "What did you like about the Web-based project?" and "What improvements would you suggest for the project?"

Analysis of data

Only 51 students used the same code names on the two surveys. Consequently, to ensure the two groups contributing pre- and post-intervention data were identical, only these students' data were used. The mean and standard deviation were calculated for each item on the two surveys and t-tests for difference of means were carried out. A subset of items in the survey, on the affective component of computer conferencing, was tested for statistical trends using a t-test for paired two samples for means. Items on beliefs about mathematics were also analysed using a similar t-test. This paper focuses on the analysis of data on computer conferencing. Detailed discussion on beliefs can be found in Schuck and Foley, 1998. Responses to the open-ended questions attached to the post-intervention survey were grouped according to the most common themes expressed by the respondents. These themes were: collaboration; novel ways of learning; access to information and others' views.

The reflective journals of all students were carefully read and permission was sought to use this material in the study. The researchers noted any reflections written about the use of the conferencing tool, and after reading all the journals, they copied extracts from a selection of the journals. The extracts chosen were either representative of the comments made by most of the students, or gave a different perspective on the use of the technology. Often a reflection would be copied because it expressed clearly the sentiments shared by a number of students. Any reflection that gave rich and deep insights into a student's view of the use of the conferencing tool would also be copied.

When the journal data were analysed, it became evident that there were four major categories of interest: *Beliefs*, related to students' beliefs about the learning and teaching of mathematics; *Technology*, related to the Web-based conference, and other aspects of the use of technology; *Evaluation*, relating to material evaluating any aspect of the subject; and *Workshops*, relating to the measurement workshops. Constant comparison techniques were used (Bogdan and Biklen, 1982) to code the journal material. It was found that all the data were accounted for in these four categories, and that the categories were not mutually exclusive. Journal material in the

Technology category provided data for this paper which expanded on the themes that had arisen in the open-ended part of the survey. Thus triangulation between methods (Delamont, 1992) occurred.

Results

Tables 1 and 2 show the most common themes about the use of the Web-based tool expressed by students in the open-ended questions attached to the post-intervention survey.

Table 1: Summary of open-ended responses to a question in post-intervention survey

What did you like about the web-based project? Most common themes	No. of responses (n=88)
Opportunity for group collaboration	35
Novel way of learning/ opportunity to use the Internet	15
Access to others' responses / seeing other views	11
Negative response	17

Table 1 demonstrates that students saw positive elements in Web-based conferencing and that by far the most common theme was an appreciation of the opportunity for group collaboration. Short extracts from different student journals further illustrate this theme:

> Top Class has been really an important and helpful part of the course. It allowed us to share and discuss our ideas and beliefs through the readings and from different group responses we have learned a lot from each other [sic].

> About four of our group members spent over fifteen hours just discussing the statement. We could have easily completed the task in an hour or two, however the concept of sharing ideas and opinions etc. became such a rewarding experience in itself that we got carried away.

> The second Top Class assignment was also very good because it enabled me to develop my opinions even further. I was able to access the assignments of all the other groups and read what they thought on the subject. I think that this method of computer conference is very useful, because it allows a greater field of information and ideas. It also makes the world a great deal smaller when experts are able to comment on your ideas on the Internet.

The next most common theme in the responses related to the novelty in this approach to learning and the opportunity to use the Internet (n=15).

> The Web based project was good, as it gave me a good opportunity to use the Internet. This was good practice for me and a learning experience.
>
> It is always fascinating how we could use the computers (net) to do the assignment. "What a wonderful world".

Students also appreciated the opportunity to see the views of others in the discussion site on TopClass (n=11). The following journal excerpts on this theme also illustrate several powerful aspects of the Web-based approach to learning: making each group's responses to the focus statements available to every other group tended to motivate students to produce their best work, and also made transparent the range of quality of the work, from mediocre to outstanding.

> By reading all the responses it also reinforced and repeated information and opinions over several sittings and finally, it certainly made you think about the topic and the 'exquisiteness' of the human mind
>
> Went in and read the Response 2 contributions - these were of a much higher standard than Response 1. Again it had pretty much all been said, but it has been a learning experience. Because we were all reading each others' work, it had many people to perform better - be more self-conscious than normal.
>
> Met today with maths group to work more on second [part of the] assignment. After being so disappointed with the results of the first activity (it was the worst result I have received during my time at uni.) I was keen for us to work as a group through the entire process ... After reading the other responses it was obvious that ours was definitely not as clear and concise as others. I hope we are more successful this time.

The contributions of the mathematics educators provided a sense of immediacy in the material that students were required to read on the Web and provided them with a range of alternative viewpoints. One group was surprised and gratified when one of the overseas contributors posted comments on their discussion response. A student commented on the difference it made to her when photographs of the mathematics educators were placed on the site, thus making their responses seem more personal.

The open-ended questions also asked about the difficulties students might have experienced with the technology. Table 2 reveals the difficulties encountered by students participating in the project.

It can be seen that of 90 students who responded, 59 (65.5%) had difficulty with the technology. Some students had problems posting their responses because of confusion about the posting process in TopClass. At the discussion site, there were two similar icons for mailing - one to post a

response in the discussion (an open envelope), and another to post a private message to the subject coordinator (a closed envelope). Consequently, some students sent their responses to the coordinator, while thinking it had been sent to the discussion site. No indication that the posting had been sent to the subject coordinator appeared on the system. The response appeared simply to 'vanish'. When their responses did not appear on the discussion site, groups would post over and over again until the coordinator would have up to twenty copies of the same response in her mail. This situation led to a great degree of frustration for some students, especially as deadlines for posting approached.

Table 2: Summary of difficulties reported in open-ended responses to post-intervention survey

	Difficulty with technology	Difficulty with collaboration	Difficulty with content
No. of responses	90	82	80
No. reporting difficulty	59	51	23
Most common themes	Difficulty posting responses: 19 System downtime: 20 Problems logging in: 18	Coordination of meetings: 17 Uneven contributions: 14 Groups too big: 8 Too many opinions: 8	Understanding and interpreting readings: 7

Other difficulties leading to frustration and resentment related to system downtime and various problems associated with logging in. Again, several quotes will illustrate the prospective teachers' perspectives on this question. The final one shows how negative attitudes can form because of frustration with the technology, despite a seemingly positive outlook on the Web-based approach.

> With the TopClass site, it was initially, simply the process of gaining access, later it became the problem of identifying whether mail and documents had been sent - a major flaw in the program.

> The TopClass program, I feel, was a good idea, but with some drawbacks that I found frustrating. One was the trouble our group had with posting the assignment onto Top Class. We were forced to hand in a hard copy because of the problems we had and then posted the assignment after the due date. I feel that this defeated the purpose of the assignment to a certain extent, but I realise that these problems could not be helped.

> TopClass was often very frustrating because it always seemed to be down when we needed to get onto it, or put our response in. This was the only frustrating bit of the assignments. After this sort of experience with the computers, I am tempted not to use them again for such purposes - if it had been more successful I may have a better attitude towards the process.

An interesting extract from a journal illustrates how frustrating the experience of using computers could be for some of the students:

> I feel somewhat the same about Information Technology as I do about mathematics although my frustration with that topic has developed only recently. When I read that the first assignment task was to include use of the computer facilities, my immediate reaction was ... a double bogey!
>
> Half of our first tutorial was spent in the computer laboratory. I was positive at the outset, however by the time I left the lab I was feeling the normal anger and frustration that I feel in those rooms. In retrospect, it wasn't because of the software I was using although it would not let me log-out and my search for assistance was protracted as the computer 'help' person was busily engaged with other problems. Other nursing students were printing out lecture notes and only occasionally stopping to let others print. My task in the assignment had been designated as readings from the Web and I was trying to print out all 7 of them in order to decide which ones to consider in depth. My assignment co-partner, had dashed away to another commitment so by the time I had achieved my goal and logged out, it was dark outside and several hours later.

Even though students liked various aspects of the collaboration required in the project, 51 out of the 82 students who responded to the question about difficulty with collaboration (62.2%) reported some kind of dissatisfaction with the process (see Table 2 for the most common themes). It appears that the size of the groups (up to six members) contributed to some of these problems. For example:

> Everyone had different opinions, therefore it was hard to come up with one opinion.
>
> My group left me out of almost everything.
>
> I didn't like it at all. My group were not motivated, cooperative, or willing to take time out of their important and busy schedules to do any work! Group assignments suck!

The data gathered on the open-ended question about difficulty with the content (see Table 2) showed that a majority of the students, 57 out of 80 (71.2%), did *not* experience difficulty. Those that did have difficulty most commonly reported that they had problems understanding and interpreting the readings. The researchers were satisfied that content had been pitched at a satisfactory level with some degree of challenge, but not beyond the capability of most students.

The survey data gave more information about the effect of the difficulties associated with the technology and collaboration (see Table 3 below). As explained in the Analysis section above, two sets of data were produced by matching student code names on the pre- and post-intervention surveys (n=51). Two tailed t-tests showed many significant statistical differences between the means gained on the pre-intervention and post-intervention surveys, but instead of there being gains, as the authors had hoped, most of the means decreased.

Table 3: Two tail t-test on differences of means for items in pre- and post-intervention surveys for sets matched by code names of students

	Pre-intervention survey n=51		Post-intervention survey n=51			
Items on computer conferencing (CC)	mean	s.d.	mean	s.d	t-value	p
CC will be an interesting way to learn	**3.4**	**0.6**	**3.0**	**1.2**	**-2.11**	**<0.05**
I have a clear idea of what is involved in CC	2.6	0.8	3.4	1.0	4.42	<0.01
It will be fun learning to use CC	**3.3**	**0.8**	**2.9**	**1.0**	**-2.21**	**<0.05**
Using CC will give me more time to think about my ideas before I had to share them	**3.5**	**0.8**	**3.1**	**0.8**	**-2.50**	**<0.05**
I have sufficient skills to use CC	3.4	0.9	3.9	0.5	3.43	<0.01
CC will give me opportunities to work with other people	**3.9**	**0.3**	**3.8**	**0.5**	**-1.21**	**>0.2**
My learning with CC will be helped by my familiarity with computers.	**3.9**	**0.7**	**3.6**	**0.7**	**-2.14**	**<0.05**
Teacher education courses should introduce students to current approaches to information technology	4.2	0.6	4.1	0.5	-0.91	>0.1
Working collaboratively with CC will make me feel more confident	**3.7**	**0.7**	**3.1**	**1.3**	**-2.87**	**<0.01**
CC has benefits that are not available using other approaches	**3.6**	**0.4**	**3.3**	**0.9**	**-2.15**	**<0.05**

Questions on Internet and computer usage						
It is useful to be given opportunities to use the Internet to gain information	**4.1**	**0.5**	**4.1**	**0.8**	**0**	**=1**
I think computers can help my learning	**4.0**	**0.7**	**4.0**	**0.5**	**0**	**=1**
I am a competent computer user	3.6	0.8	3.8	0.8	1.25	>0.1
Computers make it possible to provide more learning opportunities than traditional classroom teaching	3.9	0.6	3.7	0.9	-1.31	>0.05
Computers are soon going to be an important part of primary school education	**4.3**	**0.4**	**4.1**	**0.7**	**-1.75**	**>0.05**

(Items in **bold face** indicate the affective/valuing component of the survey)

Of the three items that displayed an increase in the mean, one item showed a significantly increased understanding of computer conferencing, as expected after the intervention, and the other two items indicated growing confidence in computing (though not significant at the 5% level) and computer conferencing skills. However, for those items that related to the students' perceptions of the value of computer conferencing, and their feelings about it, all but one item had significant decreases in their means, indicating a decrease in valuing of computer conferencing. Further indication of this trend was furnished by the paired sample t-test. This gave a clear indication (at the 1% level of significance) that the intervention led to a decrease in the overall mean for the affective/valuing component of the survey. The authors' tentative explanation of this result is that the frustrations with the technology, both hardware and software, and some difficulties with collaboration, clouded the students' view of their computer conferencing experience.

One of the benefits of Web-based conferencing is clearly the flexibility of location it offers. In theory, students can contribute to the discussion from all over the world. In reality, however, this may not be so easy. The journal entries below illustrates the experiences of a student using the conferencing tool from a distant location:

> After having tried unsuccessfully for almost a week now to connect his laptop to the British phone lines, my father has decided I should use alternative methods to access the Top Class site. It seems that the internet and other forms of information technology are not so prevalent in England. Well, I don't know about in London, and the other large cities, but here in

> Shrewsbury, Shropshire, people still seem to prefer to do things the tried and trusted old fashioned way.
>
> Having said that, however, my uncle has located a friend with internet access at his office. He has very kindly given me permission to go and use his computer.
>
> Sandy [the lecturer] did say that I could be the guinea pig as far as the 'world-wide' aspect of Top Class was concerned. Thus far I have decided that these things sound wonderful in theory, but, well, perhaps a little more difficult in practice.
>
> Success! I have accessed Top Class, and printed out two articles from the Web. Unfortunately I haven't received any messages from anyone in my group. Come on, guys ... please tell me what's going on. I sent Anna, our group leader, a message telling her which articles I chose and asking her to confirm that these are OK.
>
> I had a few problems with Top Class. I'll have to find out what was going on when I get back. I wrote quite a few messages to Anna for the group but got no replies. So I don't know if the readings I did were OK, and I don't know if they got my ideas about them or not.
>
> Back to Uni! It turns out that Anna tried to reply but the messages somehow didn't get through properly. I'm still not entirely sure what day it is or what time it is, so I won't try to [work] it all out.

So this student experienced difficulty in getting connected, but even after that, the use of the Web was not unproblematic: she did not receive any feedback from her group about her contributions. It appears from her final entry that some attempts were made to reply to her, but that either they were not sent correctly, or there was some difficulty with the technology.

The authors' own experience with TopClass was relatively satisfactory. They found the setting up of the discussion site to be very straightforward, and met with few instances of unreliability in the system. One drawback in TopClass is the inability to make multiple email postings, so that when the assessment mark and comments were posted, they could only be sent to one individual at a time, a somewhat tedious and inconvenient arrangement.

Overall, the discussions posted by the groups were satisfactory. In particular, the lecturers could see tangible improvement in the quality of the second posting - a point commented on by some of the students themselves. This improvement was quite possibly due to factors mentioned earlier: the awareness that their own work would be displayed publicly, and the opportunity to see the quality of the work of other groups.

The authors also found that the intervention did achieve its primary goal of challenging the prospective teachers' existing beliefs about the nature of mathematics. This was evidenced by significant statistical results when the t-test was applied to the beliefs section of the survey. Details of this aspect of the study are reported in Schuck and Foley, 1998.

Discussion and conclusions

As noted in the introduction the potential of the conferencing tool for collaborative work, examining alternative viewpoints, and improving student writing appear to be promising. The design of the intervention provided opportunities for students to examine alternative viewpoints. Comments both by students (see earlier extracts from journals) and lecturers indicated improvement in the quality of writing. Evidence was provided in the reflective journals and surveys that students' viewpoints were challenged. Many students valued the opportunity for collaboration afforded by the Web conferencing, and it was clear that there were benefits in having students writing for a Web community. However the statistical data from the pre- and post-intervention surveys showed that prospective teachers did not appear to believe that their learning had been enhanced by the Web-based conference.

Many of the students identified the collaborative aspect of the project as the feature they liked the best, despite the problems that many reported. The introduction of material written especially for the discussion by mathematics educators from several different countries provided a useful way to establish international links and broaden the collaboration to that of a world wide community of learners. Furthermore, the way in which both prospective teachers and mathematics educators participated in the discussion, posting their responses to the focus questions then continuing the discussion with a further posting, points towards a process by which the division between the 'novice' and 'expert' can be broken down.

However, contrary to the expectations of the authors, the overall mean of the affective/valuing component decreased in the post-intervention survey. It appears that the unreliability of the system and lack of clarity of aspects of the Web-based tool led to much frustration for student users. While acknowledging the potential value of such a tool for their learning in the reflective journals and open-ended survey questions, the pre- and post- intervention survey results suggest that many students became

disenchanted with the technology, and negative about the use of computer conferencing.

If Web-mediated components are to be included more widely in the delivery of subjects, subject developers need to ensure that ongoing technical support and timely information about the limitations of the conferencing tool are available for all students. The potential of the conferencing tool for enhancing learning can only be realised if the technical difficulties involved in using the tool are minimised. While this study showed that the use of Web-based conferencing for enhancing communication and collaboration is a valid one, it also showed that the affective component of any learning situation must be considered and catered for. Much of the reason for the negative trend in students' attitudes towards the technology was due to a feeling of lack of control and frustration when the system did not operate reliably. Clearly, reliable and easily accessible hardware and software is essential if the promise of Web-based conferencing is to be realised. The alternative is frustration and resentment in the students who are meant to benefit from this new technology.

It is interesting to note that the goals of the intervention appeared to have been achieved: alternative viewpoints were accessed, student writing improved, and collaboration was generally fruitful, as revealed in the group discussion postings and notes on collaboration. If further research had not been conducted on the affective component of the intervention, a different picture would have been painted. Hence the results of this paper point to the necessity for thorough and rigorous research on all aspects of use of computer based technology.

The study highlighted the need to consider questions on which aspects of the technology could and should be replaced by more conventional paper methods. For example, one of the students reported printing out all material before choosing what to use - surely it is a better use of resources in such cases, to have hard copies available for students.

Finally, the following issues are foregrounded as areas needing further discussion if the use of Web-based conferencing is to become a more effective learning tool. Because home access to the Web is likely to give students a greater advantage in the use of the technology, a question of equity is raised: ideally each student should have remote access. Also, the role of the technology must be examined - if it is merely a tool, then it

should not obstruct the pedagogy or the content being learnt. Or is the technology itself driving the pedagogy and content? Before there is greater use of Web-based conferencing, these issues and others must be examined so that the relationship of technology, pedagogy and student learning is enhanced.

Implications for practice

The authors drew a number of implications for practice in response to the findings from this study. These implications have been useful in the design of the subject for its second offering in Semester 2, 1998.

1. *Improving collaboration.* Comments from students indicated that some of the difficulties in collaboration were a result of the group size (six). To improve collaboration, the new design has two teams of three students interacting with each other. These teams interact on a weekly basis over six weeks, with a final single response collated by both teams. This allows smaller group discussion and more frequent responses with better feedback to the lecturers on the teams' progress.

2. *Guidance by staff.* More guidance needs to be provided for students especially in the early stages of the discussion. Initial work by students has been planned to occur on campus at a time when a lecturer is available to assist with difficulties that might arise - for example when first posting responses onto the Website. Only when students are confident to do so will they work more independently.

3. *Building a community of learners: Question and Answer Web page.* A new element has been introduced whereby students can learn from one another on the Web. All students will be able to post a question on any aspect of computer conferencing to their peers, and all students in the cohort will be invited to respond to these questions.

4. *On-going technical support.* This study found much negativity towards Web-based conferencing, arising out of problems with the technology. It is essential that 'on the spot' technical assistance be available from technical staff familiar with the Web-based conferencing system.

The trialing of the subject with these modifications will provide further evidence on how to better integrate pedagogy, technology and student learning.

Notes

[1] This paper is based on a shorter conference paper "Exploring the potential of a web based conferencing tool in mathematics" in *Proceedings of ICMI - EARCOME I*, Chongju, Korea, August 1998,Vol 3, pp. 167-179.

[2] TopClass is a trademark of WBT Systems, URL http://www.wbtsystems.com/company

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