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by Birgit Loch and Christine McDonald

It has been recognized that distance learning Web environments do not generally provide effective tools for discussion and problem-solving in mathematically based disciplines (Guimaraes, Barbastefano, and Belfort 2002; Myers et al. 2004; Smith and Ferguson 2004). Educators have employed tools such as stand-alone chat rooms successfully to engage distance students in discussions and peer-assisted learning (Guimaraes, Barbastefano, and Belfort 2002; Burnett 2003; Cox, Carr, and Hall 2004); however, most previous studies involving mathematics instruction have been restricted to typed communication in which mathematical symbols needed to be displayed in awkward LaTeX-style formalisms or image files created using Equation Editor or MathType within Microsoft Word. In such cases students usually could not respond in kind to instructor prompts (Smith and Ferguson 2004). Further proposed solutions to this problem have generally required students to have access to proprietary software applications—for example, WebEQ (Smith and Ferguson 2004)—which may pose an extra financial burden and require prior knowledge of the use of such software. In light of these challenges, many mathematics instructors may be inclined to adopt a wary attitude towards synchronous chat as an effective learning tool for their particular discipline.

The problem of synchronous mathematics instruction, however, may also be remedied in a much more convenient fashion with a widely accessible technological tool. In the following pilot study, we investigate the mechanics of employing a freely available chat client (MSN Messenger) for the teaching of mathematics to distance students. The client incorporates an electronic ink function that allows users to directly post and edit mathematical formulae and diagrams while communicating synchronously, thereby avoiding the technological limitations noted by previous researchers. In this study we explore the benefits and the difficulties experienced by students and instructors in the use of the client, and we provide the results of a course survey in which students assessed the value of MSN Messenger for distance courses in mathematics. While some functions of this client are available in the current version of the Blackboard course management system, this study may be useful for institutions that do not employ the system or for instructors who otherwise need a convenient, practical methodology because of the constraints they face in their own online learning environments.

Background

Online chats for teaching university students have been utilized in a variety of disciplines and learning environments, and their use has ranged from giving an added dimension to the learning experience of on-campus humanities students (Cox, Carr, and Hall 2004) to providing a supportive learning environment to distance students in a virtual office (Myers et al. 2004). Constructivist models of learning suggest that learners construct their knowledge by reflecting on and making sense of their own experience; consistent with this premise, Burnett (2003) notes that online instructors need to be aware of the strengths of the online chat medium by being "proactive in enabling rather than directing learning" (247). We believe the challenge lies in the creation of a learning environment where the instructor does not dominate the discussion while keeping the focus oriented to the topic.

Any effective distance education course requires a high level of interaction (Oviatt et al. 2000; Miller and Webster 1997). One objective of our study into the use of synchronous chat in mathematically based courses was to determine if this medium could provide a supportive, spontaneous learning environment in the form of an online tutorial—and thereby reduce the sense of student isolation and increase the level of instructor-student and student-student interaction in a fashion already achieved in other disciplines. We have experienced frustration teaching mathematics to distance students since the lack of suitable facilities for

discussion of mathematical problem-solving, vital for student understanding, poses a hurdle for a two-way exchange of information between instructor and student. Online instructors and students need to be able to view, edit, and post diagrams and formulae directly in their online sessions without going through laborious intermediary stages (Smith et al. 2002). E-mail and type-only discussion groups are insufficient for this purpose.

Myers et al. (2004) comment that "the needs of distance students will not be met without resorting to appropriate technology" and note that possible solutions for "highly visual disciplines such as math" are too expensive or limited to one-on-one interactions (1, 4). Until recent advances in technology that allow pen-and-paper type interactions between instructors and students in a chat environment, we had not considered using chat as a means of enhancing the distance student's learning experience in mathematics courses. However, instructors now have some further options due to these advances. Recognizing the need for a new approach to teaching college mathematics at a distance, Smith and Ferguson (2004) emphasize the importance of applications that allow users to create diagrams and graphics as well as specialized mathematical symbols; in particular, they compare the functionality of such tools as WebEQ's formula editor, based on the MATHML extension to HTML, and NetTutor's whiteboard in Web-based mathematics courses. Yet their assessment of these tools is mixed; while NetTutor proves not to be sufficiently robust, WebEQ does not allow the drawing of diagrams. Smith and Ferguson (2004) give a list of criteria for an ideal mathematics e-learning environment, and neither of these two packages meets all the desired criteria (Table 1).

We propose a different approach to enable two-way synchronous communication between students and instructors in mathematics—an approach that combines the advantages of online chats and electronic ink in a free, professional software tool.

The MSN Messenger Chat Client

The technological approach we tested at the University of Southern Queensland arose in part because of the difficulties previously experienced with our current technological infrastructure. After unsuccessful attempts at communicating with distance students via WebCT's whiteboard function—during which technical problems occurred for instructors, students, and observers (such as being dropped or frozen screens) because of the particular setup at our university—we decided to experiment with software outside WebCT. Since WebCT is presently the university's preferred CMS, other commercial packages are not available or not endorsed, and, as a result, alternatives considered for this trial had to be for free, already available, or easy to install.

MSN Messenger is a free chat client for Windows XP or Windows 2000 operating systems. This client offers an electronic ink function once Windows Journal Viewer is installed. A button allows switching between type and ink modes. Messenger is often already available on student computers and may even be the chat client of choice for most students to keep up with friends and family.

The simplicity, usability, and functionality of this popular chat client make it a particularly appealing candidate for instructional application. As is the case with other chat clients, the user composes a complete message before posting it in MSN Messenger. A posted message is added to the history, which can then be saved in rich text format (RTF) to keep a record of the conversation. Participants can refer back to previous messages by scrolling up at any stage during the chat. This approach is different from a whiteboard, where only the most recent image is kept unless recording facilities are integrated. From our experience, it is easier to scroll through text and images than through a video recording. When evaluated according to the criteria for an ideal college mathematics learning environment (Smith and Ferguson 2004), MSN Messenger receives a higher rating than NetTutor since the system is robust (Table 1).

Implementation

The pilot study was conducted over the Australian summer session 2005/2006. We selected two

mathematics-based first-year courses for this study, both of which were offered to distance students only:

- Data Analysis covers introductory statistics; the course is taken by a diverse group of students, often with a weak mathematical background.
- Discrete Mathematics is a mathematics course mainly taken by Information Technology students.

We recruited student participants to volunteer to join an online chat tutorial at the beginning of the semester. Volunteers were asked a number of questions about their previous enrollment in the course, their computer and online chat literacy, and their ability or permission to install software on the computer they were using. We were able to include ten Data Analysis and seven Discrete Mathematics students in the study.

We were not part of the official teaching team of the courses, but we ran one sequence of tutorial sessions per course. There was no assessment of tutorial participation; rather, the focus was entirely on the facility of the chat client to support effective interaction between the students and the tutor as well as among the students themselves. During the first tutorial, we asked students to experiment with the electronic ink function. Some students could not see any drawing, others could see it but not draw themselves, and a few were able to draw immediately. The former two groups were asked to install Windows Journal Viewer via the instructions in the help document of Messenger. This process was completed quickly, and only one student reported minor technical problems.

We conducted the online tutorials in a very friendly, supportive atmosphere where students could ask any questions they wished and where other students were encouraged to answer before we intervened and responded. Our role was not simply to explain mathematical concepts but rather to facilitate collaborative learning among all the participants in the tutorial sessions. We were particularly mindful of students who remained silent for some time and directly encouraged them to participate. Occasionally it was necessary for us to take the initiative and shut down student dialogue because an important topic needed to be explained to everyone before individual students asked further questions. In these cases students just listened patiently and acknowledged their understanding of our explanations when prompted. Since most students worked full time, the tutorials were initially offered for one hour a week at night. However, later in the semester these sessions tended to continue for up to two hours.

Observations and Findings

Our comparison of the initiation and use of the electronic ink function between instructor and students showed that we were mainly the ones who started an explanation with this function. Students followed when prompted or when they decided it was easier to draw rather than to type (Figure 1). We often took advantage of the feature within MSN Messenger that allowed us to drag and drop already posted electronic ink messages into the composition area to provide incremental explanations of a concept (Figure 2). While type dominated every chat session, the ink function was used to explain concepts further, to use symbols and graphs, and to show how to set out solutions to a problem (Figure 3).

Oviatt et al. (2000) observed that "during multimodal pen-voice interaction, users tend to prefer entering descriptive information via speech, although their preference for pen input increases for digits, symbols and graphic content" (268). We found a similar pattern in both tutors and students in which the typing option replaced speech for entering descriptive information and the electronic ink option was used to incorporate symbols and graphic content. Since a single message could not include both electronic ink and type, a conscious decision had to be made whether to use either option in any given case (Figure 4). Typing proved to be faster than writing in cases where text was the major component of the message.

We encountered no major technical problems during the use of MSN Messenger for the online tutorial; the software was very robust. However, we sometimes found it difficult to invite a student who had lost his or her Internet connection back into the same chat room. Opening a new chat room resolved this issue.

The summer semester is usually the most difficult semester for students since the study schedule does not allow time for a break and the semester is more compressed than other semesters. Students often find they have conflicting commitments and decide to postpone their study to another semester. As a result, not all students remained in the chat tutorial throughout the duration of the course; only three students for Discrete Mathematics and six students for Data Analysis participated for the whole semester. Judging from student feedback, this drop in participation was largely due to time and schedule constraints rather than to any difficulties experienced in the synchronous medium (Exhibit 1, Exhibit 2).

Student Responses

Students were not notified that the focus of this study was the electronic ink feature of the chat client. We used a graphics tablet and a tablet PC to draw and write on the computer while students used the mouse for handwriting. Students were not initially told that we were using a device more sophisticated than the mouse. They acknowledged that the instructor was more competent using electronic ink, but this did not seem to influence their attitude towards the tutorial.

All participating students were asked a number of survey questions (Exhibit 3) before the final examination. Student responses from eight of the nine participants (Exhibit 4) were as follows. When asked if they could imagine doing the tutorial without handwriting, they said it would have been difficult. While the tech-savvy Discrete Mathematics students used the handwriting feature nearly as much as the instructors, the Data Analysis students did not and commented that it was difficult to use. One Data Analysis student stated that it was difficult to use the handwriting tool with a mouse because she was left-handed; however, she was the student who used it the most. All students agreed that while they may not have been comfortable writing themselves, they were comfortable reading what was written in electronic ink. Furthermore, they appreciated the fact that it was most useful for graphs and diagrams; moreover, it effectively replaced verbal explanations that would have involved terminology that students were still struggling to retain.

Cox, Carr, and Hall (2004) remark that "online chats . . . should be integrated into the course design; otherwise students will not see the need to participate" (191). While this claim may be generally valid, our experience indicates that it may not always be true. The distance students in this case were grateful for the tutorial support, did not suggest that the tutorials be assessed, and remained sufficiently engaged with the tutorials despite the fact that the sessions were voluntary. Moreover, students even reported that they used the chat outside the tutorial hour to discuss further problems and to help each other. All students said that it had been worth the time involved and that they would attend this type of tutorial if it were offered for other courses; some students commented that the online tutorial helped their understanding of the course material most. Our experience suggests that even if such synchronous tutorial sessions were incorporated in a limited, voluntary fashion within distance courses in mathematics, they would significantly enhance student engagement and student learning.

Conclusion

We propose the use of a chat client with electronic ink facility for teaching mathematics at a distance, and we recommend MSN Messenger as a convenient and viable tool for this purpose. The practical advantages that the MSN Messenger chat client offers are that it is free, that it tends to be already available on students' home computers, and that many students are experienced with the chat function through chatting with friends and family. It is simple to install the additional handwriting functionality; while some students may need some preliminary time to adjust to this feature, its use is straightforward, even with a mouse. Most importantly, the range of user features is sufficiently flexible to support interactions in which diagrams, symbols, and graphic charts can be quickly created and easily modified to illustrate mathematical concepts. Rather than pursuing a cumbersome series of operations to produce such graphics, instructors and students can generate illustrations in a matter of seconds and thereby devote more time to dialogue, questions, and feedback.

Since the completion of our pilot study, the results from a follow-up study are currently being analyzed. In this

study, asynchronous problem-solving discussions were replaced by chat tutorial sessions; MSN Messenger was also used to offer consultations in a virtual office environment. Preliminary results indicate, once again, a small uptake. Students who participated for the entire semester voiced their enthusiasm and gratitude for the online learning environment and its support. Future directions of our study may include a Voice over IP (VoIP) client with a video conference facility, but at this stage such an option will not be possible for simultaneous use for more than two participants with MSN Messenger.

Smith and Ferguson (2004) state that "most online mathematics instructors still wait for a simple and convenient way to communicate two-way with their students in the very language of mathematics" (694). We believe that we may have come a step closer to this goal by using synchronous chat and electronic ink with MSN Messenger.

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