The Use of Electronic Question and Answer Forums in Mathematics Teacher Education

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Many mathematics educators share a view of mathematics as a social and cultural phenomenon and believe that the learning of mathematics concepts is developed and enhanced through the use of learning communities. Electronic discussion boards provide one avenue for supporting such social learning. This paper discusses the use of a Question and Answer section of a discussion board in a first year mathematics education subject for primary student teachers, and the way in which this facility fits with ideas of social learning. Theoretical perspectives of social learning in mathematics through the use of an electronic community are explored. Examples are given of how learning was developed through questions and answers in the mathematics education subject and insights shared regarding the various uses of this facility by the students. Issues related to participation, peer misconceptions, learning styles and teacher intervention are raised and discussed. The paper concludes that for students who are comfortable with the use of electronic conferencing, there is value in Question and Answer facilities in raising autonomy and supporting conceptual understanding of mathematical concepts, but that the medium does not suit all learners of mathematics.

Over the last two decades, education has been undergoing major paradigm shifts. These shifts include changes in theories of learning from transmission to constructivism and moves from teacher-centred to student-centred control of learning situations (Barker, 1999). As in other areas of Higher Education, mathematics educators in teacher education have the challenge of conveying this different vision of learning to their students. Students' initial expectations are that the lecturer will act as an "expert" transmitting valuable information and telling the students what they need to know to perform well in their chosen occupation (Schuck, 1996). These expectations can cause tensions in mathematics teacher education subjects when lecturers emphasise active construction of knowledge by students and student autonomy as being central to their approaches to the subject.

Consequently, in our subjects the mathematics teacher educators employ computer-mediated conferencing as one of the means of challenging student beliefs about learning, teaching and mathematics education (Schuck & Foley, 1999). This paper focuses on the pedagogical value of using a Question and Answer facility in computer-mediated conferencing. It is my purpose in this paper to illustrate how the use of Question and Answer interactions on the Web fits well with views of learning as a socio-cultural activity. The paper also contributes to the debate about peer misconceptions and about student expectations about learning.

It is becoming increasingly common for teacher educators to base their teaching philosophies on principles of social learning (Putnam & Borko, 2000). Social learning situations involve learners in actively constructing meaning, not in isolation, but in collaboration with others. Salomon and Perkins (1998) suggest that

learning usually entails some social mediation. They elaborate on two forms of social mediation of learning: (1) active social mediation of individual learning, whereby a person or a team assists the individual's learning, and (2) social mediation as participatory knowledge construction, whereby learning is seen as "a matter of participation in a social process of knowledge construction" (p. 4). This paper focuses on the second form of learning and discusses how a question and answer forum can contribute to shared knowledge construction in mathematics education for student teachers.

A dilemma exists for mathematics educators who wish to encourage student teachers to share collaboratively in knowledge construction. On the one hand, they wish to act to enable learners' development of new mathematical insights and mathematical abilities; on the other, they act as 'gatekeepers' in leading students to construe the objects of their learning in an appropriate manner. Consequently, the decision by the teacher educator to interpose with an opinion or suggested course of action can be a delicate one. Both teacher educator and students may be concerned that lack of intervention by the teacher educator will lead to the propagation of misconceptions. An added difficulty can be the student's view of the teacher educator as 'expert' where the expectation is that the teacher educator will simply 'tell' the student what is required (Baker & Dillon, 1999). However, the lack of teacher intervention may also contribute to the creation of learner autonomy, and to orienting the learner towards the community rather than to the teacher alone. The modelling of this type of behaviour in the mathematics education classroom in teacher education programs is of importance in providing examples of how prospective primary school teachers of mathematics can encourage autonomy and peer learning with their future students. This issue of intervention in the use of the electronic question and answer section of the mathematics education discussion board is discussed further in this paper.

The Use of Computer-mediated Learning to Promote Participatory Knowledge Construction

The research literature on computer-mediated learning indicates that computer-mediated conferencing tools are especially well-suited for providing the social environment that encourages collaborative construction of knowledge (Blanton, Moorman & Trathen, 1998). A number of researchers have reported on the advantages of Web-mediated conferencing where students have collaborated in learning tasks (e.g., Collison, Erlbaum, Haavind & Tinker, 2000; Sherman, 1995).

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 & Louis, 1997) cites four pedagogical principles which help to foster a community of learners: (a) activity where the learner actively participates in the discussion; (b) reflection where the learner reflects on and analyses his or her own thinking; (c) collaboration in which the learners support each other's learning; and (d) community, where a class is seen

not as just a collection of individuals, but as a learning community. Web-mediated conferencing would appear to be well suited to the utilisation of these principles.

How Question and Answer Forums Fit in a View of Social Learning of Mathematics.

This paper discusses the aspect of a mathematics education subject in a teacher education program, in which students were encouraged to use a Question and Answer (Q&A) discussion forum created in a web-based conferencing tool. For me, the introduction of a Q&A section fitted well with my theoretical framework for teaching, one in which socio-cultural factors are seen as important in learning (Salomon & Perkins, 1998; Schuck, 2002). I believe in the importance of communities of learners (Brown & Campione, 1990) and in opportunities to create rich questions or to encourage students to pose their own questions for investigation (English, 1997). I also value opportunities for debate amongst the students in which the teachers are not constructed as the sole "experts" transmitting facts (NCTM, 2000). The Q&A section appeared to serve this context well. In what follows I discuss this use of the Q&A facility and also raise issues about participation and teacher roles.

The Study

First year primary teacher education students at an Australian university are enrolled in a mathematics education subject in their second semester. The subject is primarily offered in face-to-face mode on campus. However, one component of the subject involves the use of a computer-mediated discussion tool. A Q&A forum has been placed on the Discussion Board in this tool and students are encouraged to post questions about the use of the technology or about the content of the mathematics education subject. One component of the subject is the study of measurement, which has the aims of developing student teachers' understanding of the underlying concepts as well as teaching student teachers how to teach topics in measurement in the primary school. Students are encouraged to develop their understanding of the measurement concepts, and how to teach them, by posting questions on the Discussion Board. Students are also invited to respond to any of the questions or statements made in this section. In this way students act as advisers for each other, or share ideas on any of the issues raised in class. Students generally have the necessary technical skills as they are required to participate in other forums in this subject.

The reason for having a Q&A forum as part of the Discussion Board (there are a number of other forums operating simultaneously, on different aspects of the subject) is that it appears that the Q&A activity can model quite well the shifts in practice advocated by the reform movement in school mathematics. These reforms encourage students to work as mathematical communities and to use logic and mathematical evidence as verification, rather than accepting the teacher as sole authority (NCTM, 2000).

My intention in the subject is to provide opportunities for students to participate in a learning environment which reflects these reform ideas. I am also eager for students to develop models of learning that do not limit their perceptions about who may be the "authority" on questions of mathematics or mathematics learning.

Although there is no direct assessment grade given for interaction in the Q&A section, students are given a participation mark for their work in the whole subject, and this participation can include interaction in the Q&A section if the student chooses. However, there are other ways that students can choose to be graded for participation, including participation in face-to-face discussions.

Methodology

Research Topic and Design

In this study, I used a qualitative paradigm involving interpretive inquiry (Erickson, 1986; Lincoln & Guba, 1985). This meant that I did not start out with a research question testing a particular theory and therefore searching for evidence that would prove or refute this theory. Rather, my research question concerned a phenomenon to be studied (Strauss & Corbin, 1998). I was interested in the area of computer-mediated communication and how it could be used in mathematics teacher education. I wished to develop a deep understanding of the experiences of the student teachers. My research question therefore was "How do first year students use a computer-mediated conferencing tool in their learning in a mathematics education subject?"

Data were collected that would shed any light on students' experiences in this area and analysis of that data then led to theory building in an inductive manner (Strauss & Corbin, 1998). In doing the study, I acknowledged my views about learning and about research which are discussed above, and which would obviously influence my interpretation of the data. This is not seen as a limitation of this qualitative paradigm, but rather a characteristic of such research. Making the researcher's assumptions explicit allows the reader to understand the lens from which the data is collected and viewed (Heshusius, 1994).

Participants

All primary education students in the teacher education course at our university are required to study the mathematics education subject in their second semester. In the study, I considered the experiences of all 150 students enrolled in the subject.

Data Collection

I evaluated the Q&A section by monitoring the content that appeared in this section of the Discussion Board. We also had a mid-semester evaluation in which students were asked to write what they liked and disliked in the subject and what

they thought about the Q&A section. These evaluations were anonymous. Finally students' written reflections on their learning during the semester were also examined for relevant issues. Students were required to keep a reflective journal and this was submitted to the lecturers in the subject at the end of the semester for two reasons: firstly, to give the teaching staff some valuable feedback on the students' understandings of the various mathematical concepts, and secondly, to encourage students to keep the journal up-to-date. The journals were not part of the assessment for the subject, but keeping a journal was a requirement of the subject. Permission was obtained from the students to use these data. For this paper, I will discuss some of the issues that students raised and also give some examples of powerful learning that took place through the Q&A facility.

Analysis

Analysis involved getting familiar with the data about a number of different aspects of the study. Categories were formed about the students' views regarding the online communication, and the ways in which the tool was used in the mathematics education subject. The data were read and then the responses coded into the appropriate category. Once coding was complete, I read through the data in each of the categories and "conceptualised and classified" responses (Strauss & Corbin, 1998, p. 66), thus contributing the theory building to the study.

Results

Findings from the Question and Answer Section of the Discussion

There were three major categories into which students could be grouped according to their experiences with the Q&A Forum. These categories were: (a) students who did not use the forum at all, (b) those who used the forum but did not see its value, and (c) those who used the forum and found it valuable. A fourth category showed how students used the forum.

Only about 40% of the 150 students used the Q&A forum. Of those who did, 66% found it interesting and worthwhile. Others using the forum were critical about its use. Each of the three groups is discussed in more detail below.

Students Not Using the Forum

Almost 60% of the students did not visit the forum at any point. There were a number of reasons for their lack of participation. For many, the lack of ready access to computers and the Internet from home was a problem, although they were able to use computers at the university at any time. For others, these interactions were not viewed as meeting their needs. Some of these students indicated a certain lack of familiarity with communication through an electronic network, and did not tend to visit the site as it was foreign to their normal routine. Others felt more comfortable interacting face-to-face with their peers. This point matches the findings of Selwyn (2000) who had similar experiences in a network of special

education teachers. It supports the view that electronic learning environments do not suit all learners (Hartley & Bendixen, 2001) and the opportunity to learn in different ways, using different tools and approaches should be offered to all learners.

Student Using the Forum but not Seeing Its Value

Most students using the forum were positive about its use. However, 34% of students who used it were critical of its use and expressed a number of views in the anonymous evaluations: some felt that they had nothing to say and were being coerced into using the discussion as it would give the lecturers a good impression of them, others found difficulty in accessing the site. Some other students were concerned that their peers' answers to questions might be incorrect and they were worried that they would not be able to assess whether this was the case. This last issue is one that is often problematic in student-directed learning in the mathematics classroom and leads to a great dependence by students on the teacher as the only authority.

One characteristic of the interactions, which was paralleled in the face-to-face interactions, was that usually a core of students would participate in the online discussion. For these students, there were obvious benefits demonstrated (see next section). Others visited the forum but did not interact and were silent observers. Comments in these students' evaluations were mixed. Some saw the forum as being of value and their comments are discussed in the next section. Others commented on the uneasiness they felt in interacting in this medium, or on the lack of relevance the forum had for them.

Students Who Found the Forum Worthwhile

For those who did participate in the Q&A forum, their interactions appeared to be useful and, as demonstrated below, for a number of students the discussions encouraged reflection and understanding that might not otherwise have occurred. The data in this category showed that students had found the forum useful, and had also appreciated support from their peers. The diversity of questions that could be asked was also found to be helpful and students enjoyed sharing their experiences and questions about those experiences while on a teaching practicum. Being able to ask questions or to share teaching experiences without having to be on campus, was valued by this group of students. Of the group of students who did not contribute to the forum, but did visit it, some said that they had gained from visiting the forum and reading other students' contributions.

Examples of How the Facility was Used

The following discussion thread shows an example of how students reflected on a mathematical concept and how some appear to have benefited from the process of having to justify and explain their views. The concept had already been explained and demonstrated in class, but still appeared to be problematic for many

of the students. In a desire to continue the reflection about the problem, I raised it again in the Forum, as I was aware that there was still some confusion among some of the students. Progress appears to have been made in the Q&A Forum.

A question had been posed in class as to how the area of an irregular shape could be measured. A student (George) responded by saying that the border of the shape could be measured with string and then that length of string could form a circle and the area of the circle could be calculated. We discussed the concept and George's response to it, but I could see that there was still confusion about it for many students. We did not discuss the question further in class, but asked students to think about the solution, hoping that the reflection on the concept would lead to further discussion, or clarification of the question. We had hoped one of them would pose it in the Q&A section but it did not appear that students were considering the question further. After waiting a week, I decided to pose it to get the discussion going. Part of the reason for raising it in the discussion forum was to reinforce the idea that developing understanding of mathematical concepts is not merely about accepting an authoritative view on the subject, but on justifying a line of reasoning in a way that achieves consensus from the mathematical community involved. All names have been changed in the discussion.

From: Sandy   To: Maths Education 1

Date: 18 August

Subject: Does a piece of string fix the area of the enclosed region?

An interesting suggestion came up in the lecture on Monday. To find the area of an irregular shape, it was suggested that a piece of string should be put around that shape and the length marked. Then the piece of string should be formed into a circular shape and the area of the circular region enclosed worked out using the formula for area of a circle.

My question to you all is: will this work? How can we find out if this is a valid way of working out the area of the first shape? What are the implications of our results?

Think about this, and please give a response - the process of reasoning, justifying your viewpoint or changing it if another explanation is more plausible, is all part of conducting mathematical inquiry. So go for it!

From: Annie   Date: 19/8   8:04:53

The irregular shape could be made by pushing in some of the edge of the circle. This pushing in would decrease the area of the circle, but the length of the string, or the circumference would stay the same.

From: Nguyen   Date: 19/8   9:24:02

A piece of string does not fix the area of the enclosed region. Think of it like this:

If you measured two squares (which are alike except for a smaller 'square' missing portion of one square) with a piece of string. Then placed that string in a circle, the area would be the same. However, the area is obviously not the same is it?

If I served the same two square 'pieces of cake' to two 12 year old children would they complain? Yes, because the area of one is larger than that of the other.

Why is the area not the same?

How do you put it in words?

Annie and Nguyen have thought about the problem and have understandings about the relationship between the length of string and the area, but Nguyen is wondering how to explain that concept further. Their contributions show that, while they are not reacting to each others' views, they have thought further about the concept and how to clarify it. When Harriette responds, she is not reacting to their views, which could be because they do not have sufficient authority in her eyes. Harriette demonstrates that she still has misconceptions about the topic.

From: Harriette   Date: 20/8   15:20:14

Imagine that you have a piece of string that's 40cm long and you make about 5 shapes out of it. Use all of the string every time and don't change the length, so that when the shape is finished the two ends meet. If you do all of these, the string can only cover 1 area, regardless of the shape. The only reason the area would change is if only some of the string is used etc.

At this point, I wondered if I should intervene, but my strong belief that coming in as an authority would stop any further discussion or thought about the topic stopped me. Towers (2002) talks about the problematic issues involved in "blocking" a student's line of inquiry, and it was a similar view which persuaded me to let the discussion continue and intervene later if necessary.

From: Jenny   Date: 24/8   10:42:35

I understand that the size of a piece of string does not directly effect the area of a shape but am curious about how a teacher could explain this to a student. To them it would seem logical that the area could be calculated by using a piece of string to get the circumference and then working out the area by using a formula, as I am ashamed to say it did to me when I first attended the lecture.

Jenny appears to have developed some understanding of the concept since the lecture, which demonstrates that she has reflected further about the problem. However, like Nguyen, she is still unsure of how to explain the concept to students.

From: Hua   Date: 24/8   10:53:17

Yes, this does measure the required area. it seems though that if tertiary education students can't grasp this concept as i had trouble with as well , how do we explain it to children who are struggling with maths in a general basis.

Maybe the way we do it is to demonstrate the process by measuring standard size objects like squares and rectangles and circles that have the same area and then apply it to larger, more difficult things.

Hua does not seem to have taken any notice of the above discussion. Perhaps it was not convincing her. She certainly admits that she is struggling with the concept.

From: George   Date: 31/8   8:27:16

I know it's been a while but this is the first chance I've had to go through the forum to answer this question since I brought it up in the lecture.

I don't think my brain was switched on fully that morning, but I guess that my thoughtlessness in suggesting same perimeter = same area has given us all something to think about.

I did realise moments after I made this suggestion that what I said couldn't possibly be right. Here's how I realised my mistake:

Imagine having 8 matches and forming them into a square, each side having a length of 2 matches. This area can be seen to be made up of four smaller squares, each side having a length of 1 match.

If we take two matches that form a corner of the large square, and turn them to be pointing into the middle of the large square, so that the shape is now an L-shape, we can see that this new shape has an area of 3 smaller squares, each side having a length of 1 match.

So we have used the same perimeter (8 matches) to make two different areas.

P.S. If anyone has trouble understanding what I'm saying, do it yourself with the matches, otherwise see me about it and I will explain further (you know who I am).

From: Nguyen   Date: 31/8   14:05:54

Subject: Great Response!

An excellent way to show students/children the answer.

This is a clear illustration of how different conceptions are articulated. The discussion went to and fro with no argument convincing the other readers until George stepped in with his response. As noted above, earlier in the discussion, I found myself to be in the dilemma of wondering whether to intervene and "correct" the statements that suggested that the area was fixed by the length of the string. The desire to "give the right answer" was particularly strong when I read Harriette's, Jenny's and Hua's postings. Jenny appeared to be asking for help and the other two seemed quite convinced that the length of the string determined the area. However, happily, I did not enter the discussion, leaving the way clear for George to reflect on his original response and think about ways of justifying his argument. It is worth noting that the 13-day long discussion terminated after his clear response (apart from a few words of admiration from Nguyen). Students' concerns about not recognising whether a solution to a question was valid or not, were dispelled when they read George's response. George's response in fact appeared to clear up two misconceptions for the students, one regarding the area of irregular shapes and one regarding students' abilities to discern when an argument made sense. I believe the fact that George's well-articulated explanation

was the only one to attract a direct response and that no further misconceptions were voiced was evidence that George had assisted some of the students in understanding the concept. I do not believe that my intervention would have produced any different result. Further, I believe that students will develop a better understanding of the processes of mathematical thought through the kind of reflection and justification shown here than through a demonstration or exposition by the lecturer.

Other Examples

Some of the questions were about use of the technology, for example, questions about how to change passwords or how to print. Students were quick to respond to their peers and seemed to take some pride in knowing how to help.

Other questions led to discussions about how best to teach topics. The following message starts with a question of fact, then broaches an important issue about the teaching of measurement. One reply develops the discussion about teaching, while the other gives a very succinct answer to the question.

From: Merilyn   15/10   19:54:20

Could someone be kind enough to explain the use of hands when measuring the height of horses, why not use metric measurement? Whose hands are they anyway?

From: Jamie   17/10   13:31:40

Merilyn, in reply not specifically to the use of hands for horses but in general for informal measurements, I feel it is important for children to be able to use various types of different measurements like hands, feet etc. People in general may not always have access to metric measurement devices like a 1 metre ruler etc. It is far easier to use a measurement of a foot or hand etc. than try to guess something that measures a metre.

From: Sloane   17/10   20:27:53

A hand equals the average width of a man's hand, which is said to be 4 inches or 10 cm. Therefore, a horse that stands 14.2 hands i.e. 14 hands and 2 inches is 58 inches or 147 cm high. A horse is measured from the ground to the highest point of the withers.

Other examples enabled students to share teaching ideas when they were on the practicum in schools. I provide the first posting below, which was then answered by a number of students all offering ideas and suggestions and reporting on their experiences. The discussion was useful in developing students' ideas for teaching. The students wrote with enthusiasm about these early teaching episodes and they appeared to be eager to support one another in the suggestions they offered.

From: Sarah   14/9   9:18:28

After completing my measurement lesson to a year two class and speaking to some fellow peers who taught a measurement lesson to an infants class I have found that

the idea of using stations is not always suitable and practical, due to a shortage of resources in the schools. I was wondering if anyone has taught a successful measurement lesson using the concept of stations and if so, what made it successful? I would be very interested to hear from people who took an infants class.

Sarah's question generated numerous responses and a fruitful discussion sharing ideas on teaching using workstations was generated. Some of the responses indicated that students were eager to use each other's suggestions.

The above are only a few of the examples of the diverse way the Q&A forum was used. In the next section the benefits of such a forum and the issues arising from its use are discussed.

Discussion

The Q&A forum had much to offer in the way of collaborative knowledge construction. There was clear evidence of reflection occurring, for example, in George's case, where such reflection might not have occurred without the Q&A forum acting as a stimulus. Students valued their peers' opinions and developed their ideas both about mathematical concepts and about teaching these concepts. The input from other students was trialled and it was clear to students when that input was authoritative. Students learned how to make an argument and justify their reasoning.

Further, accessibility was an important factor with this forum. While students were at schools on practicum, they were not able to contact their colleagues or lecturer except by electronic means, and usually desired contact was after school and out of work hours. The opportunity to share ideas with others was limited to the student teachers and teachers in the school at which they were located, if they did not interact electronically. Through the Q&A forum students could share ideas and ask each other for advice and they were not restricted in whom they could approach, nor when they could do this. The advice shared while students were on practicum was supportive and encouraging and those involved in the forum benefited from the discussions that arose on practicum.

So the Q&A forum was instrumental in developing a community of learners. The four principles noted in Sherin et al. (1997) of activity, reflection, collaboration and community were all present in the interactions in the forum. For those who did participate in the Q&A forum, a community of learners had been developed through its use.

The role of the teacher educator here was to set up some of the problems, to ensure that conceptual understanding of content was being developed, and to act as an observer of the activities, only stepping in when absolutely required. This fitted well with my view of learning and the role of the teacher.

However, it must be noted that less than half the students chose to participate in the Q&A forum. Although the forum was used regularly and was found to be extremely useful to many of the students, there was also a large number of students who did not access the forum at all. This raises the issue of participation and whether it should be made compulsory for all students, given the benefits of

participation. In the evaluations of the forum, the non-participating students gave reasons for not accessing the forum as not enjoying using this technology, not having ready access, time, or opportunity, or not seeing the need for it. These reasons need to be respected and it appears that unless students can see value in using a particular approach to learning, that they should not have to use that approach. This suggests that those students who prefer to interact in other ways should be encouraged to do so and alternative ways of learning should be provided in all subjects. A respect for individual differences is central to ideas of effective mathematics education.

Recommendations and Conclusions

For students who are familiar with discussion forums and whose learning styles are supported by electronic discussion, there are clear benefits of a Q&A Forum. For those who do not see the value of the forum, the situation is less clear. Reasons for non-participation are critical. If the problem is lack of access or difficulty in using the forum, then provision of access from the university site and support in use of the conferencing tool should be emphasised. Indeed, as the Internet gains in popularity and its use becomes more widespread amongst education students, the lack of familiarity with discussion boards will decrease.

However, for those students who learn better by interacting in face-to-face learning communities, this option should always be available in undergraduate mathematics education courses. Some students express themselves better orally, others find it hard to use the limited formatting of the conference tool to draw diagrams and prefer to do that freehand. Others feel diffident about expressing their views in a written (and hence permanent) form. Consequently, it is recommended that options for question and answer facilities should include face-to-face opportunities as well as electronic discussion boards.

The benefits of electronic Q&A forums are great for those who are comfortable using them. Opportunities are provided to reflect, to share ideas with others, and to evaluate arguments and discussion on merit rather than authority. Autonomy is encouraged in this type of interaction as students work together to develop their understandings. As a way of encouraging social learning, the forum has many merits. It serves well as a model for interactions in the mathematics classroom.

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