Using Study Groups to Support Mathematics Learning in Preservice Teacher Education

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Primary preservice teachers usually do not have strong knowledge nor positive attitudes towards the study of mathematics. In a context where educators need to explore effective and cost-effective modes of delivery, forms of pedagogy that support learning and affect are needed. This project investigated the use of study groups within a primary preservice program in supporting students learn aspects of mathematics. Guidelines and future areas of concern are provided.

Researchers have noted that the mathematical understandings of primary school teachers are often poor (Kaminski, 1997; Kanes & Nisbet, 1994) and that many students enter their study of mathematics and mathematics education with a sense of reservation (Carroll, 1994). Often these attitudes towards mathematics can be a result of the students' experiences in secondary school mathematics (Biddulph, 1999). The powerful effect of their earlier experiences in mathematics often means that when students enter teacher education, they hold strong (negative) views of mathematics. Such views are quite resistant to change and as Schuck (1996) has shown, the earlier experiences of students have the potential to frame their professional lives if they go unchallenged. Employing agencies and government authorities are demanding teachers have strong levels of competency in the areas of literacy and numeracy. Within this context, it is critical that preservice teachers exit their programs with high levels of numeracy and are not fearful of the subject.

In concert with these hurdles for mathematics education, the higher education context has been severely cut economically. This means that many of the [supposedly] fat pedagogies of teacher education are no longer viable in today's anorexic institutions. This is in a context where greater numbers of students from wider range of backgrounds and mathematical experiences are entering preservice courses. In these new times, effective practices are needed that must be economically viable and sustainable and cater for the diversity in the student population. In this context, this project investigated the use of study groups as a means to address these concerns. Students formed small groups where they could support each other cognitively and affectively in the learning of the course material. In these small groups, they were able to attend sessions where they could work in their groups, or seek advice from teaching staff when they were unable to resolve questions within their study group. In this context, the research problem posed was to evaluate the effectiveness of study groups as a pedagogical tool within the context of preservice mathematics education. Arising from this problem, two research questions are addressed in this paper.

- How were study groups used by the students for learning mathematics?
- What benefits do students see from participating in study groups?

Literature Review

While there are difficulties with the use of constructivism as a discourse (Zevenbergen, 1996a), its strength lies in the recognition that students come to construct their understandings of mathematics through interaction – with both the physical world and the social world. Central to constructivist positions of learning is that the learner enters the learning context with a set of assumptions, beliefs, and prior knowledge that provides the lens for subsequent

construction of meaning (Cobb, 1991; Cobb, 1994; Cobb, Yackel, & Wood, 1992). These factors impact on how and what students will construct from a given learning episode. This approach is central to the theoretical experiences that preservice mathematics teachers have in their learning about young students as learners of mathematics but is also central to their learning of concepts within the course of study.

For students coming to learn mathematics, prior knowledge, experiences and beliefs impact on their subsequent learning. For students who have had positive experiences of mathematics, their capacity and willingness to learn mathematics is likely to be substantially different from the students who have had less positive experiences in learning mathematics. This difference must impact on how and what students will learn as a consequence of their encounters with mathematics learning. In related studies of students learning mathematics (Hagedorn, Saidat, Fogel, Nora, & Pascarella, 1999) it was found that there were substantial differences in mature age students and school leavers. In these studies school leavers were defined as those students who undertake tertiary studies within 3 years of completing post-compulsory secondary schooling. Such studies have shown that mature age students enter the learning contexts willing and eager to learn but with low skills and confidence. However, they are more likely to exceed their school-leaving peers insofar as achievement levels when they exit from their studies. However, support was needed to help this cohort of students realise their goals.

Preservice Teachers Understandings of Mathematics

It is widely recognised that preservice teachers have limited understandings of mathematical concepts and processes (Cooney, Shealy, & Arvold, 1998; Taplin, 1992). Such studies have demonstrated that preservice teachers often hold very broad misconceptions about mathematical concepts. For example, a common misconceptions is that the addition of two common fractions is simply a case of adding the numerators and then adding the denominators eg _ + _ = 2/6 rather than finding a common denominator and then adding the "same" fraction ie $^{2}/_{4}$ + _ = _. The difficulty for teacher education is to reteach these basic concepts in order that exiting teachers have an understanding of why processes and procedures are adopted in order that they do not misteach such concepts to their students. In most cases, what is proposed is a shift from doing mathematics to understanding mathematics.

Preservice teachers also enter their initial training courses with poor attitudes towards mathematics and often full of self doubts as to their capacity as a mathematics learner (Cooney et al., 1998; Philippou & Christou, 1998). In most instances, the negative attitudes they hold towards mathematics as a discipline and towards their capacity to learn mathematics, become stumbling blocks to their learning. Indeed, if students believe that they do not like mathematics and their capacity to do mathematics is restricted, then their subsequent capacity to participate and learn mathematics is restricted and so engenders a self-fulfilling prophecy. In order to alleviate the effect of poor perceptions – of self and mathematics – considerable support for the students is needed. In considering the current context of higher education, such support is difficult to provide within the traditional forms of pedagogy offered with the sector.

Study Groups as a Medium for Learning

The use of study groups for learning has been used across a number of contexts and for a range of purposes. It has been widely explored as a tool for professional development among practising teachers (Charles, 1995; Crowther, 1998; Murphy, 1995; Powell, 1992) and school administrators (Mohr, 1998); and in the higher education sector (LaBonte, 1995; Woods, 1996). Within the area of content, it has been used across a range of curriculum areas

including literacy (George, 1997; McCutchen, 1993); social studies (Grimes, 1996); chemical engineering (Woods, 1996); and Spanish classes (Llyod, 1996). In these studies, the use of study groups has been found to help students gain confidence in the nominated curriculum areas. Learning outcomes were reported to increase with the gains in self confidence facilitated by the use of study groups.

The use of study group to aid among at-risk students (McCutchen, 1993; Mercure, 1993) has been found to be highly successful. It has provided a forum through which students are able to work with students at similar levels of understanding and are less intimidated by knowing others. In such environments, students were found to be more active in their learning and gain greater confidence in the areas being covered. It has also been used successfully to support mentor programs where the beginning teacher is supported by a practising teachers (Devlin-Scherer, 1993) for similar reasons cited in other studies.

These studies indicate the breadth of use of study groups as a tool for learning. In most cases, the effectiveness of the use of study groups as a tool for improving learning outcomes (Downs, 1995); confidence in the subject area and/or as effective professional development (Charles, 1995) has been documented.

In summary, preservice teachers are likely to enter their study of mathematics with very different experiences of mathematics and very different levels of mathematical understandings. From constructivist standpoint, these different learning experiences will impact on students' capacity and confidence to learn mathematics. The economically constrained and highly accountable context of higher education poses a big challenge for teacher education to deliver content to students. Study groups have been shown to be highly effective across a number of different studies. As such, this project explored the use of study groups within a teacher education program within the narrow context of the students learning the mathematics component of their course of study.

Method

Students undertake a core subject in their preservice degree (the first of three mathematics education subjects). The subject integrates subject knowledge (mathematics) and pedagogic knowledge (mathematics education). Study groups were implemented as a way in which students could undertake supported learning. The form of the study groups progressively evolved over the semester as a consequence of an action learning model. Using focus groups and random surveys, the needs of the students formed the basis of the evolving study groups.

The subject had an enrolment of 150 students, with approximately 45% of the students being mature age, 80% of the total students being women. The course of study involved students undertaking the study of mathematics up to a Year 10 level but with most content focused on the primary school mathematics content. Student had to gain an 80% pass rate on both of 2 quizzes in order to pass the subject.

Students were given the option to form study groups and 4 extra sessions were provided to support the learning of the students (on a needs basis only), but also to provide a physical space for students to meet whether or not they may have needed support from teaching staff. The project evolved whereby three of the workshops where used in the manner intended by the project, and one group becoming its own study group.

Data Collection

The project cited here is from a much larger project where a number of tools have been used to collect data. The data cited in this paper comes from focus group discussions. These were used to compliment other forms of data collected throughout the project.

Focus Groups – At the completion of the subject, two focus groups were held. A series of semi-structured questions were asked and students were able to respond. Focus group meetings were tape recorded and transcribed. Students were also asked to complete individual responses to the questions that were posed. The questions posed focused on the strategies they used in their groups, identifying key aspects of the approach that they felt were critical to effective learning; and the effectiveness of study groups in their learning of mathematics.

Discussion

The discussion is centred on the three questions related to the research questions:

1. What strategies do preservice teachers employ when working in study groups to negotiate and enhance learning outcomes?
2. Does the use of study groups facilitate a growth in the affective domain of mathematics learning?
3. Does the use of study groups facilitate change in self-reported learning?

A range of strategies were used in and across the study groups but central to all their meetings and discussions was the use of worksheets. A series of worksheets were made available through the library website as the text book questions were very unclear and many redundant for the subject. The questions were highly focused on what was essential knowledge for primary school teachers and were based on the particular content strands being covered. Answers were provided with the sheets. In all groups, the worksheets formed the basis for discussions and meetings. These were seen by all groups as useful tools to focus their work and discussions rather than as the focus of their work.

Strategies Used by Student Study Groups

From the focus groups discussions, it appears that there were a number of distinct strategies used within the study groups. The strategies were adopted to more or less degrees across the groups, depending on the activities being undertaken and group dynamics. These included reliance on a particular group member who was seen to be somewhat more knowledgeable than the others; using the study groups as a form of support – both moral and mathematical; and a group that had a special mix of needs and hence relied more on teaching staff.

Strategy 1: The Collective Experts

This strategy tended to have a experts who were relied on more heavily than other members of the group, depending on the work being undertaken. This person/s would offer some advice when the group would get stuck. After input, the group would then work on their tasks again.

> S: We just worked through the worksheets and the people that could... Sandy got everything – she'd sort of go at how one hit and we'd say "Sandy, what does this mean" and we'd sort of help each other and when we got stuck on Question 11 or something, and then we'd all come back and meet again and work it all out together, say the different ways that go to the conclusions.

As a group, they relied on a range of resources to help them through the content, including their peers. This strategy was often inclusive of most group members as at different times, different group members would have the necessary knowledge.

> S1: We worked as a group, especially for the tests, together, going through the worksheets and doing the problems as they arose, comparing answers and referring
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> S2: to [the lecture notes] if we needed to as we went along. If we found there was a discrepancy in our answers or one of us wasn't quite sure, the others would model it for them and try to explain it. If we weren't sure, we'd go to [the textbook] and we found that worked really well. We just methodically worked through the chapters that way.

Many of the older students commented that they could work out answers but would not understand why they undertook the methods that they did. For example, the new method of subtraction with decomposition is very different from 10 years ago so many of the older students had difficulty with this method whereas the younger students had grown up with the method so were very familiar with it. The younger students were able to tutor their older peers in this task.

Strategy 2: The Supporters

A second strategy tended to use the group for morale so that the group took on a role where they would support and motivate each other as well as providing a forum in which they could discuss the mathematics. The more affective component of the learning was seen to be important in this strategy. This is evident in the comment:

> S: I think that is where working in a group helps because you don't give up. There is someone there to support you and someone there that perhaps has grasped the system [the procedure used to calculate and answer] and whether we yelled at each other or were frustrated with each other, we eventually got through it and everybody understood. If you were on your own you would tend to give up.

Strategy 3: The Directors

This strategy was not the type of self-directed study group that was envisaged for the project. In contrast, this strategy was used by students when they could not work out particular problem. It was a dominant strategy used by a particular group, which comprised "very" mature students (some with adult children) and who felt that they needed more teacher-directed input. One woman commented that she did not feel comfortable working in a group as her ability and confidence were so poor as it had been so long since she had done maths that the study group format tended to confuse her more. Another member had a hearing impairment so had many gaps in her learning and she felt somewhat different from her peers and preferred to work with her teachers. This group met during one of the workshop sessions and would work through the work sheets and would raise areas of difficulty. They sought greater input from the staff than the other group. In many ways, this was the most disempowered group of students as they lacked the confidence to work through problems in small groups of peers. There was a strong perception that the teacher was the expert and that this was their best way to meet their needs as they could get too confused with diversions.

> S: I found the small group sessions with you [the lecturer], where it was the small group, that we were able to ask questions and if we didn't understand it, you'd go through specifically for us. I guess that's the way our brain functions, we're all a bit different and you eventually got some method that we would understand.

Interim Conclusion

The value of the study group as forum for learning was unequivocal. Students saw the value of the study groups as providing a forum in which they could negotiate tasks and answers in a manner that was non-threatening and supportive. The study group environment allowed students to work together in ways that they were able to negotiate and develop. The different strategies indicate the range of techniques used by the students to negotiate and learn the mathematics of the subject. Students consistently stated that the study groups gave them a chance to work together and have mutual gains. This was often done within the context of a very social gathering.

Study Groups and Learning Outcomes

Two means for documenting learning outcomes can be used. In the first instance, there were just over one third of the students who failed the first quiz and needed to resit the quiz. These students were predominantly the students who made use of the study groups and extra

support provided. When students sat the second quiz, only 10% of the total cohort needed to resit the quiz. This suggests that the learning of content had improved potentially as a consequence of the use of study groups. On it own, such statistics suggest only correlation, not causation, so at best, it can only be claimed that the study may have been useful in improving learning.

At a more subjective level, students reported that they learnt a lot more through the use of the study groups. They reported that when they did not understand particular aspects of the content, the study groups provided a forum where they could talk with their peers and say, without fear of being labelled as incompetent, that they could not understand something. Through discussions with their peers, they learned how to work through problems and why they undertook some procedures and not others. In many cases, the explanations reinforced what they had heard and read, but became far more contextualised and hence meaningful. The study groups provided a non-threatening forum in which they could discuss their lack of understanding without fear of ridicule, which enabled them to understand the work more clearly. This is summed up in the comment:

> S: I think when you have a study group, you work together as a group. I think it is a lot better because not everybody thinks the same and so you're getting ideas of how to maybe cut out a step, do it a bit different and of a sudden you go "oh yeah, OK".

The value of study groups can be aptly summed up with the following comment in which a student is discussing her transition from working solitary for most of her life and the value she experienced through participating in study groups where the students talked about ideas and problems.

> S: Oh the realisation that I was just going to learn it so much better and it was going to be so much easier if we shared it and sat down and talked about it, rather than trying to sit there [alone]. At school I remember sitting and writing down and learning stuff for history- rote and writing it out, writing it out, and I've just realised at Uni now that I don't learn by writing it out. Why did I ever do that? I don't know anymore. I actually learn by talking about it.

Implications for Teaching Practice

Within the new contexts of higher education, new forms of effective pedagogy are needed. This project has investigated the value of a particular strategy - study groups - that offers potential for teacher education. The format of the study group is very flexible and can be adapted to cater for the needs of the participating students, something not possible within the normally rigid structures of large scale lectures and tutorials. What was clear in this project was that mature age students predominantly used the study groups. Some younger students participated within some groups, but this was not common. Insofar as further research, this aspect of focus groups could be explored more. Many of the younger students said that they did not need study groups as they had only recently left school so their knowledge of mathematics was still fresh and hence did not need extra support in learning. The break between the value of study groups as a medium for cognitive, affective and social learning has not been recognised by the younger students whose focus is still utilitarian and focused on passing the subject.

What was clear from the discussions with students was the need for focus within the study groups. It would appear that it is essential for the group to have some tasks that give the group purpose and structure. The use of the work sheets proved to be an invaluable catalyst for discussions about the mathematical concepts and processes. In this study, the value of the focussing activity was not recognised until later in the project when students identified their value. In subsequent implementations of study groups, greater attention can be directed at the

types of activities that can be offered as there appears to be significant value in this focused activity. In all cases, the work sheets were foundational to the activities and discussions that occurred within the groups.

The use of study groups cannot be seen to replace teaching but rather should be a support for learning. The results of this study indicate that some groups of students need extra support in learning mathematics. Study groups have provided a very useful forum in which students have greater control over their learning and hence gain more confidence in mathematics. Through discussions with peers, they are able to offer support and be supported by their peers in the learning of mathematics. While such learning is invaluable, it is necessary to provide contact with teaching staff during periods so that students are able to access staff when they encounter brick walls and problems cannot be resolved at the group level. This input is left until the students identify that they need some extra external support.

The results of this project are indicative of the potential of study groups in higher education, however, more work needs to be undertaken in order to identify the most effective strategies for improving learning and affect while maintaining an economic and pedagogic viability. This project has identified the value of study groups within teacher education along with a number of principles that have been useful in organising the same.

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