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Study Groups as a Tool for Enhancing Preservice Students' Content Knowledge

Robyn Zevenbergen
Griffith University

This paper explores the use of study groups in a preservice primary mathematics education subject where discipline knowledge (mathematics) is integrated with pedagogical knowledge (mathematics education). In order to address the well-recognized fear and competency levels of preservice teachers in the study of mathematics, study groups were explored as a medium for enhancing learning – both cognitive and affective. Overall, those students who used study groups reported that they were very effective forums for enhancing cognitive and affective learning outcomes in mathematics.

Shulman (1986) has identified two forms of knowledge that teachers need – content knowledge and pedagogic knowledge. In mathematics education, the content knowledge refers to mathematics. Knowing how to organize this knowledge in ways that can be developed by students requires pedagogic knowledge, that is, knowledge of teaching practice. Collectively, good teachers need to have both areas of knowledge in order to develop sound teaching practices in mathematics. However, primary preservice teachers often are not confident with the study of mathematics and generally have low levels of understanding of many mathematical concepts (Kanes & Nisbet, 1996). In many cases, preservice primary teachers have opted for studies in areas other than mathematics so when they enter their courses they have low levels of mathematics content knowledge and frequently have an anxiety towards the discipline (Goulding, Rowland, & Barber, 2002). The development of a strong content knowledge is central to the development of quality mathematics teachers. For example, Mandeville and Lui (1997) concluded that the level of teacher knowledge impacted significantly on the learning of the students whereby teachers with high levels of mathematical understandings provided higher quality learning opportunities for their students than did their peers with limited understandings of mathematics. Thus, the role of teacher education is to develop beginning teachers into confident and competent consumers and users of mathematics in order that they are better able to teach mathematics.

Within this context, it becomes critical to support preservice teachers in developing their content knowledge while exposing them to practices that will challenge their existing epistemological assumptions about mathematics. How to organize such shifts within the constraints of higher education became a challenge for teacher educators. Seeking to develop independent learners, who see mathematics as socially-negotiated required an approach that was viable within a climate where there were decreasing resources available to teaching staff. To this end, study groups offered potential to the organization of learning for preservice teachers. This paper reports on the use of study groups within a suite of two

subjects, the ways in which students organized their learning within the study group format, and recommendations for the development of effective study groups.

Preservice Teachers' Mathematical Content Knowledge

Many primary preservice teachers have tended to specialize in areas other than mathematics after they complete the compulsory years of schooling (i.e., beyond Year 10). This has resulted in many preservice teachers entering their teacher education courses with low levels of mathematics knowledge as well as considerable anxiety towards the subject (Brown, McNamara, Hanley, & Jones, 1999; Cooney, Shealy, & Arvold, 1998; Taplin, 1992). Taplin (1992) and Simon (1993) have raised concerns about primary preservice teachers' weak conceptual knowledge and Cooney et al. (1998) have noted similar difficulties with secondary teachers' content knowledge. In their study of preservice teachers in the UK, Goulding et al. (2002) found that there was a significant link between "poor subject knowledge [being] associated with weaknesses in planning and teaching primary mathematics" (p. 699). Recognising that such as correlation does not imply causation, the authors elaborated further that the positive links were potentially due to the connection that students were making between content knowledge and pedagogic knowledge. They contended that the link was due to both cognitive and affective dimensions of the students. Being strong in content knowledge offered a sense of confidence, which in turn was realized through teacher actions. Offering a strengthened program in content knowledge gave students resources upon which they could draw as they planned their teaching. They concluded that where students had secure mathematical foundations, they had greater confidence in their own knowledge as a teacher.

Preservice teachers often enter their initial training courses with self doubt about their capacity to learn mathematics (Cooney et al., 1998; Philippou & Christou, 1998). These conceptions come to frame how they will organize learning environments once they begin to plan for teaching. This extends to practicing teachers where Bibby (2002) showed that the belief, that mathematics is about 'right answers', brings about feelings of shame amongst practicing teachers if they do not know the answers. As a consequence, this produces teaching practices that are governed by teachers ensuring they have correct answers thereby offering a restricted repertoire of learning experiences for students. Ball (1990) argued strongly that the focus in teacher preparation needed to be one that encouraged students to relearn the content knowledge in order to develop new understandings of pedagogic knowledge. In attempting to break the distinction between content knowledge and how it is taught, Ball (1990) argued that preservice teachers needed to develop connections between mathematical knowledge and teaching knowledge. Strength in content knowledge can be transferred to pedagogical knowledge. This was evident in the Mandeville and Lui (1997) study where they reported that teachers with a strong knowledge were able to provide "greater depth in dealing with concepts, better equipped to lead students to use their

knowledge and use more higher-order content than teachers less knowledgeable abut the content" (p. 406).

The studies cited here point to the importance of preservice teachers having a strong content knowledge and exposure to practices that challenge their views of mathematics. This is a considerable demand given the reduction in resources and competing demands placed on academics in contemporary workplaces. One approach that offers potential is the use of study groups. In the following section, it is proposed that such an approach offers considerable scope for teacher education.

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. The potential of the peer group as a learning support within higher education has been long recognized but relatively little is known about how peer group learning works in study groups (Downs, 1995). The format of study groups varies considerably but the overarching features are gatherings of learners who focus on particular tasks related to their field of study. They have been widely explored as a tool for professional development among practicing teachers (Charles, 1995; Crowther, 1998; Murphy, 1995; Powell, 1992) and school administrators (Mohr, 1998); and in the higher education sector (LaBonte, 1995; Sanacore, 1993; Woods, 1996). Within the area of content, it has been used across a range of curriculum areas including literacy (George, 1997; McCutchen, 1993; Radencich, 1993); social studies (Grimes, 1996); chemical engineering (Woods, 1996); and Spanish classes (Lloyd, 1996). In these studies, the use of study groups has been found to help students gain confidence in the nominated curriculum areas. Learning outcomes have been reported to increase with the gains in self confidence facilitated by the use of study groups.

The use of study groups was also found to be highly successful in supporting at-risk students (McCutchen, 1993; Mercure, 1993). Students appeared less intimidated by being able to work with other students with similar levels of understanding. In related studies of students learning mathematics, Hagedorn, Saidat, Fogel, Nora, and Pascarella, (1999) and Hirst (1999), reported that there were substantial differences in mature-aged students and school leavers. These studies have shown that mature-aged students enter the learning contexts willing and eager to learn but with low skills and confidence. While their achievement levels when they exit from their studies are more likely to exceed their school-leaving peers, greater support is needed to help this cohort of students realize their goals. Extending the use of study groups to practicing mathematics teachers, Arbaugh (2003) reported that the groups were highly effective in developing deeper knowledge of both content and pedagogic knowledge. 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 professional development (Charles, 1995) has been documented.

What is clear from the literature is that preservice teachers are likely to enter their study of mathematics with very different experiences of mathematics which impact on their learning of content knowledge as well as providing a frame for how they may organize curriculum for their students. In this context, the research reported here investigated the ways in which study groups supported and enhanced cognitive, social and affective learning outcomes for preservice mathematics teachers. While clear definitions of the composition of a study group were lacking in the literature, for the purposes of this project, a study group was defined as a small group of learners (3-6) who formed informal groups that would meet to work on set problems related to course material. Participants determined their meeting times and locations as no set guidelines were placed on them. Students were, however, expected to work through problems and share their workings. Only when they could not solve a problem, could they seek advice from the teaching team. For this program of study, the focus was to move the locus of control from the teachers to the learners so that independence and collaboration within the peer group were seen as defining characteristics of the study group format. This approach was aimed at exposing students to different ways of working where they developed understandings of learning mathematics that shifted the authoritative voice from the teacher to the learner.

Implementing Study Groups to Support Student Learning

This section provides a description of the context and the procedures by which the study was implemented.

Context of the Study

The implementation of the study groups occurred in two mathematics education subjects. The first was a subject in the first year of a teacher education course related to the study of number. The second subject was in the third year of study and encompassed the study of the other strands of the mathematics syllabus: chance and data; measurement; space and algebra. Each subject was for a full semester and equated to 25% of their course load within that semester. Through both subjects, students studied both the content knowledge up to Year 9 along with the pedagogical knowledge associated with such concepts and processes. Approximately half of the students were mature aged and had not studied mathematics for between 5 and 20 or more years, and reported low levels of confidence with mathematical knowledge. In contrast, most of the school leavers reported a greater confidence with the mathematical knowledge. Students undertook two quizzes that tested their content knowledge (up to Year 9 level), where they were required to gain an 80% pass level. While the level of mathematics may appear to be low, graduates are only qualified to teach primary school up to Year 7. With the content being two years ahead of their teaching

curriculum, it was felt to be a minimum level of content knowledge. Most students, however, struggled with this level of content knowledge.

Formation of study groups was optional. To support students, meeting rooms were timetabled. A member of faculty would be available should students need guidance on problems. In the first semester, the staff member would be available in the room while in the second subject, he/she was on call. To form a focus for their work, problem sheets were made available to students. These sheets gave a purpose to meet while providing inexpensive materials for the students as most of the students have restricted financial resources.

A number of research techniques were used to collect different forms of data to investigate how students worked in and felt about study groups. At the beginning of the suite of subjects, an initial survey was conducted for background information – how long it had been since they studied, how they felt about mathematics, how confident they were with the study of mathematics. Surveys were conducted at the completion of each semester to identify student reaction to the study group approach being used. The data from the first survey was used to inform the development of the second iteration of that subject (for the next year) and for the second subject. At the completion of the second subject, three focus group meetings were held. At each meeting, ten students attended. Students could self nominate and some students were specifically invited so that the diversity of students (in terms of achievement, attendance at study groups, etc.) were included in the focus groups. A series of semi-structured questions were asked and students were able to respond. To ensure that all viewpoints were represented, students were also asked to complete individual responses to the questions that were posed. Focus group meetings were tape recorded and transcribed. Students were given the questions in advance so that they could respond in a considered manner. Questions that formed the basis of the focus group meetings are shown in Appendix 1. The findings presented in this paper draw on the data from the focus group discussions.

Students' Experiences of Study Groups

From the focus groups, it became clear that students used a range of techniques in the study groups. The primary motivation for the study groups was the worksheets. The tasks were focused on content knowledge for primary school teachers and these became the 'unstated curriculum' for the students. The worksheets corresponded with the content strands being covered and answers were provided with the sheets. All study groups used these questions as the focus for their individual study and their study group discussions. In all groups, the worksheets formed the basis for discussions and meetings.

Study Groups: A Variety of Formats

The ways in which the study groups worked offered challenges to the epistemological views that students held of mathematics. In the initial weeks of the subject, there was considerable resistance to the study groups as students wanted

to be given the answers by the academic staff. This was evident in the quote from Ben (pseudonyms used). This type of comment emerged across all three focus groups.

> I did not like the idea [study groups] to start with as I thought it was the teacher who teaches but as the semester went on, I began to learn a lot from the others in the group. I was surprised that in most cases we could do the work without the help of the teachers. This was a big thing for me to learn. I can see that it will have a lot of application in a classroom. (Interview with Ben)

As the course progressed, the study groups began to take a life of their own. This was particularly evident as students began to experience different ways of working, seeing students in their groups work through their mathematics in different ways, and having success with their new ways of working. In supporting 'informal lectures', a strategy was used which encouraged students to model their methods to the whole group. As they had been working within their study groups, they had confidence to come to the front of the lecture theatre and model their methods. As the subject progressed, students began to have their beliefs about 'one particular method, one particular answer' approach to mathematics significantly challenged.

> The Thursday lectures were good because it reinforced that we knew stuff. Once we got over the shock of being asked to come out and show the group how we did it, it was great that different people would come to the front and show their ways of doing the same thing. I had no idea that there were so many ways of doing something in maths … we were always taught that there is only one way and that is the right way. This has really opened my eyes up! (Interview with Trish)

In the following sections, the formats used within different focus groups challenges a rigid method for teaching mathematics. Students began to experience new ways of working mathematically. Across the focus groups, common themes appeared to emerge in the data indicating that the study groups employed different dynamics within their groups. The data suggested four main themes in the ways in which the study groups managed their learning.

Relying on Experts. One theme indicated a reliance on particular group members who were seen as having a stronger grasp on the concepts or questions. In these groups, students would defer to particular members. This strategy typically centred on the worksheets as the basis for individual work. These groups would then meet regularly to discuss their work and how they arrived at particular answers. There were many occasions when a member did not know how to work out a particular question and another member would explain how to work it out. Alternatively, there were times when very different methods were used to work out answers and these would become the basis for discussion. While the method reflects common practice in many school classrooms, the rotation of the 'expert' was a significant deviation from their school experiences where the expert was typically the teacher.

> We just worked through the worksheets and the people that could… Sandy got everything – she'd sort of go at how one hit it 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. (Interview with Ellen)
>
> Sometimes, somebody picked up something very easily and they were able to model it for the others and explain it and in the end we all tended to get the idea and did OK on the last test. (Interview with Evan)

In this approach, the students relied on the teaching staff only when their group members could not solve the problem. In other cases, the support from staff was at a more affective level aimed at encouragement rather than cognition.

> Having one of the tutors there [was useful] because I think again, like I'm always looking for that reinforcement – are we doing it right, we're putting in all this time and effort into it, but at the end of it, have we done it the right way? Having somebody just say "yeah, you're on the right track, you're looking in the right direction" was good. (Interview with Emily)

As the course progressed, there was less reliance on the teaching staff. In the second course (and subsequent iterations of both subjects), the teaching staff were not in the room, but would be in the office across the hallway. Students could call on the staff member when they needed support. In these subsequent iterations of the program, the reliance on teaching staff decreased as students came to see their peers as experts. Students reported that working in the groups allowed them access to someone who knew how to do a particular aspect of the work. The person who was the 'expert' peer in one topic area may not be the expert across all topic areas so the students felt that they all had some chance to have input into the groups.

Often the differences in strategies used to solve a particular task became the focus of their meetings. Many of the older students reported that they had learned processes for calculating tasks but could not understand why they did what 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, who had grown up with the method were very familiar with it. The younger students were able to support their mature-aged peers in this task.

Using Multiple Resources. A second format that appeared among the groups was working together in a systematic way and relying on a multiplicity of tools and resources. While there was potential for the role of expert, this was seen as only one possibility among many. Unlike the strategy of relying predominantly on a particular person, there were others sources of information to consult. The textbook or lecture notes also became referent points when the group could not agree. In the group below, these three students worked as a very close group as evident in the finishing off of each other's sentences.

> 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 … (Interview with Mel)
>
> … 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 went methodically through the chapters that way. (Interview with Melanie)
>
> Sometimes the three of us sat there and we'd all get different answers, and then we'd have to "what did you do?" and then we'd go back to the book. (Interview with Margaret)

As a strategy, there was a need to have some consensus among the group, whether this was for the answer to a question, the way in which they solved a problem or deciding on what the question was actually asking. To this end, they used a range of tools to ensure that there was consistency in meaning across the group.

Supporting and Encouraging Each Other. A third format 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 as is evident in this comment:

> 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. (Interview with Sarah)

Other comments were not as overt in their recognition of the power of the group as a medium for support, but it is implicit in the comments offered:

> We like to work in the group. We didn't do any individual study for maths at all. All of our study was in a group situation. [When I did work on my own] I'd just sit there and make the same mistake five times and still not understand why I'd made a mistake. I wouldn't even bother to try and sit down and do it myself [once we were in study groups]. (Interview with Sandra)

A common theme in the focus group discussions was the students' sense of disempowerment with mathematics. Many felt that they had not had the necessary prerequisite knowledge, had been poorly taught at school, or had forgotten so much since they left school and returned to tertiary studies, while others felt that mathematics had changed so much since they had left school.

> Coming back to uni as a mature-aged student is difficult. Maths has changed a lot since I went. I can see it with my kids and I have no idea of how to help them. I did not do well at maths at school so was really fearful of this course. What has been great for me is that my peers encourage me when I get stuck. They may not know the answers either but together we stick with it and help each other till we get it. (Interview with Steve)
>
> I did not know how to do this new maths stuff. It was great to have some young people in our study group as they had done maths like we were being taught so they could teach us oldies. It is awful not knowing how to do something, so the young ones were good in helping us gain confidence with the new ways to do things. (Interview with Samantha)

With all these challenges, the need for moral support was high. The study groups provided a forum where this could be achieved and, as was common to many of the discussions, students felt comfortable in the groups as most students were operating at similar levels as their own and as such did not feel intimidated by others.

Relying on Authority Voices. The final method used by one group was not the type of self-directed study group that was envisaged for the project. In contrast, this group was made up of students who worked within two sets of constraints: the first was that they were all 'very' mature students (some with adult children) who did not form a group, and second, they felt that they needed more teacher-directed input, as evident in the quote from Ruth:

> I am so old and don't feel like I really belong at uni. I don't want to be a burden on other students as I need to learn so much about everything. I don't think anyone would want me in their group. (Interview with Ruth)

This woman commented that she did not feel comfortable working in a group as her ability and confidence were so low. It had been so long since she had studied mathematics that the study group format tended to confuse her more. Another member had hearing difficulties so had many gaps in her learning, and she needed more support than she felt she could get from a study group. 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 the input from the staff rather than wanting to work on the problems themselves. In many ways, this was the most disempowered group of students who 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 – they could 'get too confused with diversions'.

> I found the small group sessions with you, 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. (Interview with Romina)

> I need to have things explained to me so that I can then work through them. Like I feel that I need to have the teacher tell me so that I know it is right. I worry that if someone else explains something and it is wrong, then I will be wrong and not know why. (Interview with Rosalyn)

The interactions with the teacher noted by the first student are quite different from the needs of the second student. The latter seemed to subscribe to traditional views of the teacher as being the holder of all knowledge. Members of this group were the most difficult to extend in terms of their confidence (and achievement) in content knowledge. Their background knowledge was very weak, and in one case, the student exited from the program.

Links with Pedagogical Knowledge and Content Knowledge

The previous sections illustrate how students used the study groups in very different ways to support their learning. The value of the study group as a forum for learning was well supported. Students saw the value of the study groups as providing a place 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 content knowledge. What the students overwhelmingly supported was 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.

> Something that I have learnt is that in school it was always more of a competition, you did your own work, you didn't share, you just went home and did yours whereas here, we had to do a lot of work in groups, without any help or guidance [by the staff] but basically we did it on our own. I've found that you do, working together and sharing your ideas and your information is just the biggest help. (Interview with Rochelle)

This comment was representative of the support for the study groups as an effective tool for learning mathematics in an environment that was non-threatening and even enjoyable. While there was a range of strategies used within the study groups, as a whole, they offered further support for students in their study of mathematics.

Study Groups Facilitating Affective Domains of Learning

This cohort of students was no different from those of other research studies. The survey data suggested that students in this study were not confident in their knowledge of mathematics; did not enjoy school mathematics; felt they needed more support in the learning of mathematics; gained most of their learning through on-campus learning; were highly motivated to learn mathematics; and felt that it was important for them to learn mathematics if they were to be competent teachers. The responses offered by the students in the survey at the start of the semester overwhelmingly indicated that they were not confident in their mathematical understandings but were keen to learn more mathematics as it was an important area for them as primary school teachers. The number of students who felt that they needed more support varied, with some ranking it very high, while others were more confident and did not feel they needed any further support. In this context, it would appear that the use of support groups such as study groups would not be used by the entire cohort of students and as such would be unnecessary for all students. In this light, it was decided that study groups would be an option for those students wanting/needing extra support. This approach recognized the individual needs and backgrounds of students. To implement compulsory study groups for all students would not match the range of

responses indicating that some students studied in different ways and/or were more confident in their mathematical knowledge than their peers.

Comments offered by students overwhelmingly indicated that the study groups influenced the affective domain of their learning. Students reported that the study groups provided supportive environments in which students assisted each other's learning. Mathematics is often seen to be a solitary activity, yet the study groups encouraged students to work collaboratively on tasks and this was evaluated highly by students. There was also a social as well as affective dimension to the study groups. For the students who participated in them, there was a very relaxed atmosphere to learning. This is evident in the comment:

> Yeah, you can talk about it [the mathematics] and its unstructured debate. You can sort of have a bit of laugh while you're doing it and it's having fun while you're learning it. It's having a bit of a giggle and laugh, but you're still learning the content. (Interview with Sam)

This aspect of the study group process seemed to be a key feature of its success and value.

Group Membership

Approximately one third of the students actively sought and used study groups as a preferred learning tool. Those students who used the study groups found them to be highly relevant and useful to their learning of mathematics. However, the students who did access the study groups tended to be a particular section of the cohort of students – generally they were mature-aged students. Focus group discussions tended to focus on this and it was raised as an issue. Discussions with other students and final evaluations indicated the widely held perception that it was the 'older students' who 'needed the extra support'.

> The extra support has been great. We really need it, as it has been so long since we did any of this stuff that we have forgotten it. (Interview with Maxine)

Supporting this comment, but from young students, the following were offered:

> The mature-aged students need the extra support, we do not, so it is not good to hold up lectures for them. We know how to do the maths, so it is only revision for us. (Interview with Jarrod)

> Well it is really the old students who need the help. We have just come from school and know all that maths but they don't. I get frustrated when they always ask questions in lectures. I think they need to be put in other classes to give them more help. (Interview with Felicity)

The latter comment indicates the younger student's belief that the mature-aged students were in need of extra support and, as other younger students mentioned, felt that the mature-aged students slowed the pace of lessons due to their 'lack of knowledge'.

It was proposed by a number of students that the younger students have recently exited from school and have a very competitive ethos. The study group

format encourages participation and collaboration along with exposing one's vulnerabilities in the learning of mathematics. Such an ethos is contradictory to the competitive ethos that the younger students seemed to embrace when entering university. Similarly, it was noted that many of the younger students had just completed secondary school so had perceptions that their mathematical understandings were strong and hence did not believe that they needed to attend any extra support.

> I wanted to tell you about one of the young girls that I found really interesting. She came from a private school and got very high marks for her mathematics at the end of Year 12. She failed both of her quizzes [in this subject]. … She said she had a very poor education in the early part, got to the private school and she was actually taught incorrect things. She learnt all the formulas but had no understanding. She got a very good pass in Year 12. I found it interesting that she didn't turn up to the study groups … I found it interesting that she didn't put in the extra effort to make sure she was going to pass. (Interview with a mature-aged student, Marlene)

Many of the mature-aged students commented that such factors – competitiveness and sense of ability – tended to work against younger students' willingness to participate in study groups. This was considered in concert with the fact that many young students have to work and may not be able to commit to extra contact time. Overall, it was seen that a number of factors worked against younger students' participation in the study groups.

Many younger students were happy to drop in and out of the study groups when they needed some support or clarification on particular problems. Some study group members commented that their numbers would rise and fall depending on how younger students would drop into the group, particularly in the week or two prior to a quiz when it was clear that they needed help. This intermittent participation suggests that there may be some value for younger students to participate in study groups, but more needs to be known about the patterns and reasons for their participation.

Study Groups and Learning Outcomes

It is difficult to ascertain the effect of study groups on the content learning of students other than through their perceptions of how well the initiative helped support their learning. At a 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 openly, without fear of being labeled incompetent. Thus, not only were they learning content knowledge, they reported gaining confidence in their learning and were developing a more positive disposition towards mathematics. Through discussions with their peers, they developed a much richer conceptualisation of mathematics as more than a procedural process:

> I think when you have a study group and you work together as a group I think it's 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 all of a sudden you go oh yeah, OK. (Interview with Trish)

> I think I learnt a lot through our study group. I was a bit intimidated at first to say that I did not know something, but as we went along, it became easier. You didn't have to say that you couldn't do something, because someone usually could and they would help explain how they did it and then you could get a better idea of where you were going wrong. It helped me to understand things that I only used to do by rote, step-by-step. (Interview with Keith)

In some cases, the students were quite specific about aspects of mathematics teaching and content that they encountered through their study groups. In the extract below, the students had been commenting about the participation of a younger student who could do calculations only with a calculator. Since these were banned from the examination, the study group helped Caroline re-learn how to complete calculations without any electronic aids.

> Caroline is a prime example. She comes out and she goes "I can't do anything without my calculator", and she had to go and re-learn, we had to re-teach her how to do things without her calculator, and that was really good. (Interview with Michelle)

Similar learning occurred with other aspects of mathematics and the teaching of mathematics. In the extract below, the student is commenting on learning the new method of subtraction where students must regroup tens into ones and transfer these to the ones in order that the subtraction can be completed. As a result of this learning, which occurred in her study group where a younger colleague has taught the mature-aged peers this new method, the student is then able to work with her own children at home.

> Just being able to do the problems, understanding maths has helped me with my own children. When they've come home with homework and I'd said I don't know how to do this, now I'm actually able to sit down and explain it to them. Place value was one of them and it was subtraction. I knew how to do it the old way, but I couldn't show my daughter how to do it, I just couldn't and when we did it at Uni., yes! Straight home that afternoon – "I can show you now" and I explained it to her and she sat there and I said "Do you understand?" "Yeah, why didn't Miss Brown explain it like that? That's easy." It just clicked. I said thank goodness for that and she's been fine ever since. (Interview with Helen)

These examples are also useful for assisting teachers to recognize aspects of teaching mathematics and the impact that it can have on learners. While these students transferred their learning to the home environment, they had little opportunity to enact it in the classroom in the first course of study due to the negligible contact in schools. In subsequent years of the project, students reported that they used their changed learning in their teaching practicums. For example, one student reported that she implemented small group discussions in her mathematics lessons so that students could learn from others:

> When I went on prac, I asked my teacher if I could get the children into small groups to talk about their maths. I wanted to do this because I had found working

> with others in the study groups the best way for me to learn things. If I could learn from others, then so could my children. I think I will take that away from this program and make sure I use it in my class. (Interview with Gail)

Other students felt that they could claim responsibility for others' learning. In the extract below the student shares her sense of power in being able to help other students learn concepts. The students recognized that other people have very different ways of learning and that the study group gave a forum where there could be greater sharing of knowledge. This diversity in approaches to teaching and knowledge construction was seen to be a positive aspect of the study group process.

> That was actually the case I think … a lot of people didn't understand the base things [base numbers] and I remembered that from school and it was different to the way we were shown, the way I learnt it or remembered it was different to the way we were shown, so I showed quite a few people the way that I knew it and that I think was easier for a lot of people when they were shown. (Interview with Roberta)

Here the student seems to be confident and happy to share her methods of working through conversions of numbers of different bases. This type of comment was commonly elicited by the students and suggests that they felt that they had made contributions to other people's learning.

The overall benefits of the study groups were identified in the preceding sections. They are quite varied but suggest that students benefited from this process in terms of their content knowledge as well as their pedagogical knowledge. 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.

> What helped you make the transition? (Teacher)

> 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 was actually learning by talking about it. (Interview with Rochelle)

Perhaps, the most pleasing aspect of study groups was the enduring effect. Most of the students in the focus groups indicated that creating situations and a need for students to work in non-competitive environments facilitated a supportive network that many of them used throughout their studies.

> The study groups in the first year were a great idea. I got to meet colleagues who I am now good friends with. I don't think that would have happened if we were not placed in a situation where we could meet with others. The study groups we developed for Maths Ed 1 were great as I still work with the same people. Not always the ones that were in the exact group but we had mingled with other

> people in the meeting rooms so we got to know them then. I think it creates a very supportive network. I think that they will be friends when I am teaching too. (Interview with Gabrielle)

From these comments, the study group format facilitated improvement in cognitive, social and affective elements of learning.

Conclusion

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 they have 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. The changes in pedagogy and learning made available through the study group format had the effect of changing students' views about how to learn and how to teach mathematics. This was a significant change from their preconceived views of mathematics being teacher-directed and undertaken through particular algorithmic processes. As the students in this study showed, there were changes in how they came to see themselves as learners (through the various strategies used in the study groups), and how many of them saw these changes as being reflected in how they would organize learning when they became teachers.

In ensuring that the study groups were successful, a number of strategies were seen to be central to the organization of the initiative. The students needed a reason to meet. This was provided through the worksheets. The variety in methods used within the study group formats can be seen as a positive as it modeled to students effective learning strategies that they, in turn, use in their own classrooms for their students' learning. As the preservice teachers noted, they needed to know that if they came across problems that they could not solve, that there was a support person – a peer or teacher. This strategy was important as it modeled to them how they, as teachers, could position themselves within their classrooms. Students could take control over their learning with the role of the teacher being a resource rather than a source of all knowledge.

On a very pragmatic note, one key element for the success of the study groups was the provision of a place to meet. Many of the students in this program have considerable constraints on their time such as families and work commitments, so a place to meet with peers, where they could engage in conversation, was critical.

Overall, the students supported the use of study groups. Generally, however, the students who made use of the study group option were mature-aged (approx 95%). In studies of mature-aged students, it has been noted that while highly motivated, they have a need for support in their learning (Hagedorn et al. 1999; Hirst, 1999). This was evident in one of the student's comments:

> We are here as a second chance and we want to make sure we don't blow it. We don't have our parents supporting us so we really have to make sure we make a go of it, we don't want to blow it. (Interview with Greg)

Some students recognized that they had been away from school for some time so they needed extra support to relearn mathematics. Such comments encapsulated the reasons for mature-aged students' participation in study groups. However, what was of concern was the non-attendance of school leavers. While this cohort of students reported that they had high levels of confidence in their potential achievement in the courses, most of the failures in the course were from younger students. As such, many of these students who would have benefited from the extra support, did not attend. The use of study groups as a medium for enhancing learning appears to have many positive benefits. However, the approach is not being exploited by a significant portion of the younger student population and the reasons for their non attendance is an aspect that requires further investigation.

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Appendix One: Focus Group Questions

1. What techniques have you used this semester that you feel have been successful in helping you learn the mathematics content in this subject?
2. What techniques have you used this semester that you feel have been the least successful in helping you learn the mathematics content in this subject?
3. Did you use any of the extra support services offered to help students? If so, in what ways did they help you?
4. If you used the extra supports, what suggestions might you make that could make them more successful for students?
5. When you were learning various aspects of the mathematical content, what strategies did you find you used that helped you learn? - learning for understanding, passing the test, applying formulae, others?
6. How well do you think you understand the mathematics that you are going to teach?

Author

Robyn Zevenbergen, School of Education & Professional Studies, Griffith University - Gold Coast, Private Mail Bag 50, Gold Coast Mail Centre, QLD 9726. Email: <r.zevenbergen@griffith.edu.au>