

Changing the way to Teach Maths: Preservice Primary Teachers' Reflections on using Exploratory Talk in Teaching Mathematics

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This paper reports on the reflections of twenty-one primary preservice teachers following a microteaching experience that focused on the use of talk and collaborative group work, as part of a primary mathematics specialist education programme. Based on the didactic strategies of exploratory talk, the experience intended to develop knowledge for teaching mathematics in a contingent way. Preservice teachers' reflections from an online survey and from written recounts were analysed in relation to noticing students' learning and behaviour. Whilst the preservice teachers indicated that the microteaching experience impacted on their teaching, some reflections revealed tensions in noticing student learning and in balancing a focus on both collaborative talk and mathematics content. These tensions suggest that resistance to change in the practice of novice teachers may not be due just to a conceptualisation of teaching mathematics, but also to awareness of student mathematical thinking as *knowing-to*.

Keywords · preservice teachers · exploratory talk · didactic strategies · mathematics learning · noticing

Introduction

As far back as the 1970s, Barnes (1976) raised awareness of the role of communication in teaching and learning. Since then, there has been considerable research interest in developing opportunities for students to take a greater part in classroom discourse. Such research has investigated different formats of classroom communication (Renshaw & Brown, 2008) and identified typologies of student talk in small group work (Mercer, 2000). In addition, the so-called reform in mathematics education research in the 1990s instigated a focus on discourse in mathematics classrooms (e.g. Cobb & Bauersfeld, 1995). Since then, several studies have investigated the effectiveness of discourse in mathematics classrooms. A key aspect has been the identification of the Initiation-Response-Feedback (IRF) model seen as typical of mathematics classrooms (Kyriacou & Issitt, 2008), and which most lends itself to the replacement format as teachers funnel students to adopt precise terms. Further research has pointed towards other formats such as drawing on wider student experiences, privileging types of discourse within contexts, and recognising students' multiple voices (Renshaw & Brown, 2007). Chapin and O'Connor (2007) have presented strategies to support a move away from the replacement format

and the IRF model, and researchers, such as Hunter (2007), have promoted collaboration and discussion through a community of inquiry and collective argument.

Mercer's studies (e.g. Mercer, 1995; 2000) looked at typologies of talk within small group work and identified three types of talk: disputational, cumulative, and exploratory. Further studies, such as Littleton and Howe (2010) and Wegerif (2006), have investigated the use of discourse in relation to exploratory talk in small group work across the curriculum, and studies such as Mercer and Sams (2006) and Murphy, Wegerif, and Fisher (2010) have focused more specifically on small group work in mathematics. Whilst these studies have investigated how extending student talk through exploratory talk can have a positive impact on student learning in mathematics, other studies have highlighted the demand of such an approach in changing teachers' ideas about teaching mathematics (Sherin, 2002; Hunter, 2005; Murphy, 2015). This demand would seem to be heightened in relation to novice teachers, and the question of how to support preservice teachers in developing such discourse has been a priority in teacher education (e.g. Brendefur & Frykholm, 2000; Fisher, 2011). Studies have indicated that modelling talk in line with different formats and typologies in teacher education programmes does not always transfer to the classroom practice of preservice teachers (Fisher, 2011). This conundrum has been linked to the traditional views often held by preservice teachers, of how and what to teach in mathematics, and that these views relate to previous experiences (Jaworski, 2003). In consequence, preservice teachers' practices often align to the more traditional formats and typologies of talk in the classroom (Fisher, 2011).

The study presented in this paper focused on the use of a microteaching experience intended to support preservice teachers in developing primary students' exploratory talk within small group work in mathematics. By microteaching experience I mean a scaled-down instructional opportunity, where the normal complexities of classroom practice are limited, and where preservice teachers can focus on one aspect of their practice (Cruickshank & Metcalf, 1993; Mergler & Tangen, 2010). The microteaching experience was part of a primary mathematics specialist course on a one year post-graduate programme in England. The experience was based on the notion of exploratory talk as a didactic tool to support discourse in small group work, and was intended to support the translation of theory and principles of talk, collaboration, and problem solving into action in a primary classroom setting. Preservice teachers' reflections from an online survey, and from their written recounts of the microteaching experience, were examined in order to better understand the preservice teachers' awareness of their emerging practices in developing talk and collaboration in group work.

Awareness and *Knowing-to* in Teaching Mathematics

As part of the microteaching experience, the preservice teachers were required to resource problem solving tasks that would encourage talk and collaboration. Hence, the experience aimed to create contingent situations for the preservice teachers to direct and facilitate the students in engaging with mathematics problems. Whilst teacher educators often aim to reflect Shulman's (1986) idea of pedagogical content knowledge as "the blending of content and pedagogy" (p.9), the focus of most university courses has been on the disciplinary knowledge of mathematics, as preservice teachers are tested on their knowledge of content and asked to write academic assignments about pedagogy (Mason & Davis, 2013). In creating contingent situations within the microteaching experience in this study, the focus of preservice teachers' knowledge was on students' mathematical thinking within problem solving situations in the classroom (Fernandez, Llinares, & Valls, 2013; Rowland & Zazkia, 2013). That is, the experience aimed to support the preservice teachers' awareness of in-the-moment pedagogy in mathematics, rather than on static

disciplinary mathematical knowledge (Mason & Davis, 2013). The experience intended to emphasise non-static knowledge for teaching mathematics in a contingent situation (Ball, Thames, & Phelps, 2008; Chick & Stacey, 2013). Such contingent situations would require the preservice teachers to be sensitive to, and *notice*, the students' contributions in learning mathematics.

Noticing has been used widely as an aspect of professional vision in regards to how a professional group interprets events (Goodwin, 1994). In teacher professional development, such noticing promotes teacher reflection on their behaviours in relation to the students' interactions and learning. Key to these reflections is how a teacher attends intentionally to events in the classroom that are important pedagogically (Sherin, Jacobs, & Philipp, 2011). Noticing as a theoretical framework has been used previously in researching teachers' reflections and analysis in learning to teach (Erikson, 2011), and has been used widely in studies in teaching mathematics (e.g. Mason, 1998; Van Es & Sherin, 2002; Mason, 2009; Mason & Davis, 2013), as well as other disciplines such as science (e.g. Barnhart & van Es, 2015). Mason's (1998) seminal work on noticing in mathematics teaching has been re-emphasised through the idea of awareness and *knowings* (Mason & Davis, 2013) as "...imagining oneself acting appropriately in the future and using this to sharpen one's noticing in the moment, thus educating one's awareness" (p.190).

The adoption of noticing, as a theoretical stance for this study, shifts the focus of preservice teachers' knowledge in teaching mathematics from factual *knowing-that* to the strategies of *knowing-to*. In this study, the preservice teachers were asked to reflect on the contingent situations of the microteaching experience, and to envisage what alternative actions might be used to further support the students' talk and learning in mathematics. As students of mathematics or, even of mathematics education, the preservice teachers may *know that* in relation to an aspect of the discipline or in teaching the discipline. However, in a contingent situation, the preservice teachers would be required to *know to* use some tactic or strategy in order to engage the students in talk and problem solving. Not only were the preservice teachers to be aware of *knowing-that*, in relation to the mathematics content they were teaching, they would also reflect on the didactic strategies that they planned for, or were revealed in the situations, and then maybe to *know to* act in a different way. As such, the microteaching experiences were intended as opportunities to explore professional development through awareness and *knowing-to*, both in behaviour within the group work and in learning in mathematics. It was hoped that such an experience would sensitise the preservice teachers to work with their students in an informed and appropriate fashion, and that they would make connections between mathematical content and in-the-moment pedagogy.

Didactic Strategies in Exploratory Talk

Mercer (1995) defined exploratory talk as talk where students "engage critically but constructively with each other's ideas" and where "knowledge is made more publicly accountable and reasoning is more visible" (p.104). Mercer further termed such collective talk as *interthinking*, in acknowledging the link between the cognitive and social function of group talk. Previous research such as Mercer and Sams (2006) and Murphy et al. (2010) have suggested that the development of exploratory talk can encourage the sharing of ideas or interthinking in group work in mathematics, and that such sharing of ideas can support student learning. The intention of the microteaching experience was to introduce didactic strategies related to exploratory talk to the preservice teachers, and for them to apply these strategies in classrooms with groups of students.

Didactic strategies have been developed and researched in projects such as Thinking Together (Mercer, 2008) and Talking Counts (Murphy et al., 2010). Principles behind these didactic strategies aim to enhance students' awareness of the role of talk generally, and then to focus on the role of talk when collaborating with a group on a task. Prompts or ground rules for talk are developed by the teacher, along with the students, as an aide memoire when working together. The prompts are used to encourage students to question and challenge each other, as well as to ask for and to offer help in solving a problem. One key aspect of working together was to arrive at a consensus, so the prompt "Do you agree?" would be prominent, along with challenges such as "I don't agree because..." The prompts or rules are displayed and reinforced before group tasks. These prompts or rules could then be reflected on following group sessions, in order to further raise awareness of the expected discourse.

University-based sessions had introduced the principles of the didactic strategies for exploratory talk, and the preservice teachers had been encouraged to develop prompts and reflect on them when engaged in problem solving tasks. However, for many preservice teachers, the situation that they would manage themselves in the classroom would be novel. In using such didactic strategies to develop talk between the students, the preservice teachers were being asked to embark on a form of classroom communication that was different from the traditional replacement format or IRF, and hence suggested a change from Brousseau's (1997) didactic triad of student-teacher-content, where the teacher would explain, or model, the mathematics to the student. Instead, the preservice teachers were being asked to engage in a pedagogical practice that would enable the students to share ideas, or engage in interthinking, independently of the teacher. So, not only was the preservice teachers' attention focused on the students' engagement in solving a mathematical problem, they were also focusing on how they used the didactic strategies in tandem with problem solving and with learning in mathematics.

Traditionally, planning would focus on learning outcomes based on a content domain in mathematics. The exact mathematics would be determined by the teacher and identified as a learning outcome. In this study, the preservice teachers would start their planning by designing a task to encourage engagement in solving a mathematical problem through talk and collaboration, rather than to model a piece of mathematics. The design of the tasks would require the identification of a content domain in mathematics, but the tasks would be designed so that the student learning happened within the shared talk or interthinking, rather than prescribing an exact learning outcome.

The intention was that this shift in didactic priorities would instil a transition from *knowing-that*, as a piece of mathematics reflected in a learning outcome and modelled to a group of students, to *knowing-to* as a tactic or strategy to encourage and support students' interthinking in mathematics. It was anticipated that the preservice teachers' reflections on the microteaching experience would reveal what they noticed regarding their awareness of teaching and learning mathematics within such contingent situations. That is, how they were aware of the events in the situation. What did they attend to in noticing student talk and student learning in mathematics, and how did they interpret what they noticed? Furthermore, how would they consider appropriate actions for the future?

The Study

Twenty-four preservice primary teachers, ten male and fourteen female, were involved in the project towards the end of their university-based training and before their final practicum, although only twenty-one participated in the questionnaire and recounts. The preservice teachers were mathematics specialists, so they had a qualification in mathematics above the normal

requirement for entry to a primary teaching qualification in England, and some had a qualification in mathematics at degree level. In the university seminars, the preservice teachers had engaged in problem solving tasks in mathematics, and considered how a learner applies their knowledge of mathematics in solving a problem by developing their own strategies, reasoning, and generalising, and in communicating their ideas (Haylock, 2006). The preservice teachers were introduced to Mason's (2002) discipline of noticing, and were encouraged to notice their talk and learning in carrying out problem-based tasks in the university sessions. Further to this, the preservice teachers had studied the notion of exploratory talk in their academic reading, and were introduced to the didactic strategies, as developed by Thinking Together (Mercer, 2008) and Talking Counts (Murphy et al., 2010) projects. Examples of the prompts to support productive talk that were introduced to the preservice teachers and practised in the university sessions are given in Figure 1.

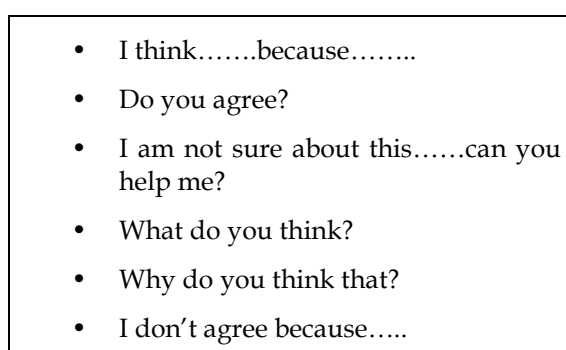
- 
- I think.....because.....
 - Do you agree?
 - I am not sure about this.....can you help me?
 - What do you think?
 - Why do you think that?
 - I don't agree because.....

Figure 1. List of prompts to encourage exploratory talk.

The preservice teachers worked in groups of four for the microteaching experience. Each group of four worked in one of six primary classrooms with a teacher who had been involved in the Talking Counts project, and so was experienced in using the didactic strategies. The microteaching experience happened in the first term of the school year, and the teachers were at various stages of introducing the strategies in their mathematics classrooms. The microteaching experience sessions were carried out once a week over a period of four weeks. Each group of four preservice teachers worked with six primary school children aged between 5 and 7 years old.

In the first week, the preservice teachers observed the class teacher setting up a mathematics task with a group of students. Each group of four preservice teachers discussed their observation with the class teacher to focus on an issue that had arisen in the students' work behaviour and learning. The preservice teachers were asked to identify an intervention to address the issue. In the second week, the preservice teachers resourced a problem-solving task based on the mathematics content being taught in the classroom at the time, and prepared their use of didactic strategies in order to address the identified issue. The preservice teachers shared the teaching and observation of the sessions with the students and discussed the impact of the tasks and didactic strategies with the class teacher. In particular, the preservice teachers were asked to focus on how changes in managing the task impacted on the students' work behaviour, how the students talked together and shared ideas, and how well the students were able to access the mathematics in the task. They were further asked to consider if they had impacted on the students' learning, for example, if they noticed any moments of insight. A further issue would then be identified, and in the third and fourth weeks the preservice teachers again resourced problem solving tasks,

developed their didactic strategies, shared the teaching and observation of the students, and then reflected on the session with the class teacher. The preservice teachers were asked to keep field notes of each session in relation to their observations and reflections.

At the end of the fourth week, the preservice teachers reviewed the impact of their three teaching sessions with the class teacher and reflected on their professional development. They were asked to reflect on whether the experience had increased their awareness of teaching strategies and mathematical pedagogy (for example, was there something new that they were now aware of?) and to identify any impact on the students' talk and learning. At the end of the experience, the preservice teachers were asked to complete an online questionnaire and to submit a written summative reflective recount of the experience. In this paper, the preservice teacher reflections from the online questionnaire and three of the preservice teachers' reflective recounts are presented and analysed.

The items on the questionnaire (as set out in Table 1 in the results section below) referred to the impact on the students' talk and mathematics learning in relation to the preservice teachers' use of the didactic strategies, and to the problem solving tasks they had resourced and developed. The term impact was meant to refer to any direct effect or influence on the quality of the group work, the student talk, and the learning in mathematics. The preservice teachers were also asked what impact they felt the experience had on their own teaching of mathematics; if they felt the experience had any direct effect or influence on their developing practice. The online questionnaire was anonymous, and the items comprised of questions with 'yes', 'no', or 'not sure' categories. There was also an opportunity for the preservice teachers to add verbal comments for each question. The verbal comments were analysed using NVivo to identify emerging themes. The online questionnaire was administered by a research assistant and was accessed by the preservice teachers in private using their personal computers. In order to protect anonymity, neither the schools nor the gender of the participants were identified.

Using the notion of noticing and awareness, the preservice teachers' reflections were analysed to understand, not just what they attended to, but how they reacted to what they attended to, and where they would be mindful to act differently (Mason, 2011). The use of noticing to inform the framework for analysis has been used in other studies to evaluate preservice teachers' ability to notice (van Es, 2011), and also their quality of noticing (Santagata, 2011). The intention of the study in this paper was not to evaluate the ability or quality of the preservice teachers noticing. There were no opportunities to compare noticing before or after the microteaching experience to determine if abilities to notice changed. Neither was there an opportunity to compare the quality of noticing with another group of preservice teachers who were not involved in the experience. Instead, the intention of the analysis was to examine what the preservice teachers noticed and the discernment of their noticing.

Results

Twenty-one preservice teachers completed the online questionnaire. Results of the quantitative data from the 'yes', 'no', and 'not sure' categories for each question are presented in Table 1. All the preservice teachers who responded to the survey felt the project had impacted on their teaching in mathematics, and 86% were able to identify particular skills that they had developed. However responses to other questions suggested some preservice teachers had not determined clearly any impact in relation to students' talk and students' learning and in relation to success in developing the tasks. Just more than one half (57%) of the preservice teachers felt they had made any impact on the students' use of talk, but several (38%) were unsure, and one preservice teacher did not see any impact. Less than a third (29%) of the preservice teachers felt they had success in

developing tasks that would encourage talk and collaboration, half (52%) of the preservice teachers were uncertain of their success, and four preservice teachers (19%) felt they had not been able to develop such tasks. The uncertainty resonated further in determining the impact on students' learning in mathematics. Less than half of the preservice teachers (43%) felt they had impacted on learning and almost as many (38%) were uncertain. Four preservice teachers (19%) did not feel they had any impact on the students' learning. The data suggested that some preservice teachers appeared to have experienced difficulties in developing the tasks, enabling the talk, and supporting learning, whereas others appeared to see opportunities in developing the tasks and in the use of the didactic strategies to impact on students' talk and learning.

Table 1

Preservice Teachers' Responses to Yes, No, Not Sure Categories from Online Questionnaire

Preservice teachers' responses (n = 21)	Yes	No	Not sure
Do you feel you had any impact on the students' use of talk?	12 (57%)	1 (5%)	8 (38%)
Do you feel you had any success in developing mathematics tasks that would encourage collaboration and talk?	6 (29%)	4 (19%)	11 (52%)
Do you feel you had any impact on the students' learning in mathematics?	9 (43%)	4 (19%)	8 (38%)
Do you feel that the project has made an impact on your teaching in mathematics?	21 (100%)	0	0
Are there any skills in particular that you feel you have developed?	18 (86%)	3 (14%)	0

The preservice teachers were invited to add a written comment for each item on the questionnaire. The preservice teachers' written comments were analysed both deductively and inductively using NVivo. Initial nodes were set deductively according to the topics of the questions above: students' talk, students' learning in mathematics, task development, and impact on teaching. In addition nodes were set relating to interthinking (students' use of talk to share ideas in mathematics) and to engagement/interaction (students' engagement on the task and collaboration in their group). Further nodes were set to code comments in relation to either opportunities or difficulties in order to explore the factors that influenced preservice teachers in determining impact or lack of impact. Matrix queries were then carried out for opportunities and difficulties against each of the nodes talk, learning, tasks, and teaching, and in relation to interthinking and engagement/interaction. Analysis carried out using these matrix queries suggested further themes:

- use of didactic strategies in relation to students' use of talk;
- accommodating tasks to meet students' needs;
- recognising students' learning;
- value of the experience to future teaching.

The first three themes were analysed in relation to whether the preservice teachers saw opportunities or difficulties, in order to identify indicative factors or phenomena. All the preservice teachers had determined some impact on their professional development, but the

fourth theme, value of the experience to future teaching, was analysed in relation to the phenomena that had appeared to present difficulties and opportunities in the first three themes. Coding against the initial nodes and the subsequent matrix analysis were carried out by the author, and hence the author's interpretation is acknowledged. As such, the indicative factors in relation to opportunities and difficulties should be viewed within this limitation and so are considered to be illustrative of potential factors.

Use of Didactic Strategies in Relation to Students' use of Talk

Several preservice teachers suggested that their use of the didactic strategies had impacted on the students' use of talk and collaboration. They remarked that the students' use of talk had improved and that the students were able to reflect on what made a good communicator and collaborator. They commented that the students learned to use phrases such as "I agree because" and to explain and justify their answers. These preservice teachers acknowledged that the students did not know how to talk and work together initially, but had needed to be taught how to talk effectively with each other.

It has made me realise that you must explicitly teach children how to work together, you cannot just assume that they will know how and be able to do this successfully.

These preservice teachers saw how the prompts and ground rules were a key part of their teaching, and that their use should be continued by outlining expectations for talk each week.

In order to receive the best possible outcome from children, they must first be very carefully taught to use the skills and guided continually.

On the other hand, other preservice teachers saw that a continued need to use prompts and ground rules suggested lack of impact on the students' talk, particularly if they needed to reinforce these each week.

By modelling the correct language the children were picking up more. Though it still remains unknown if this would have been the case without such strict guidance.

The children were able to identify aspects of good talk yet, unless prompted, would not use this within the group.

Whilst all preservice teachers saw that the initial use of the prompts was a key part of the didactic strategies in laying a foundation for effective talk and collaboration, the use of continued reinforcement was viewed differently. Some preservice teachers saw continued reinforcement of the prompts as having an impact, and recognised an opportunity for their professional development, whereas other preservice teachers saw continued use of the prompts as a difficulty or obstacle in developing their teaching and the students' talk, and hence, they felt they had not made an impact.

Accommodating Tasks to meet Students' Needs

The development of the tasks seemed to be most problematic for the preservice teachers, with only 29% feeling they had been successful. These successful preservice teachers commented how their focus moved from direct teaching of learning intentions to the nature of the task in engaging the students in the mathematics. They had focused on matching the mathematics to the needs of the students to promote sufficient challenge, and yet ensure the mathematics was still accessible. Some preservice teachers noted that familiarity with the requirements of a task meant the students could access more challenging mathematics, so they repeated the format of a task with a different mathematics topic. The issue of managing different needs in a group was also

recognised by some preservice teachers. If one student was more adept at the mathematics in the task, particularly with number work, then that student would dominate the group.

As a teacher, care needs to be taken to ensure one individual is not stifled by more domineering group members

So, these preservice teachers selected tasks that did not have a number focus.

The second activity we chose was a problem solving activity, creating shapes with straws. This was chosen to avoid children who were capable of solving the previous week's problem on their own from controlling the group.

However, many of the preservice teachers did not feel they had been successful in developing the tasks. These preservice teachers commented that the students' mathematics was not sufficient for them to engage collaboratively in the tasks. They commented that the students needed more basic mathematics principles in place before the mathematics talk could develop.

We realised to get any talk, the activity needed to be so simple that the maths was easily grasped. If the mathematics challenged their thinking, then discussion ceased.

Whilst some preservice teachers had seen the development of the tasks as an opportunity to focus on the nature of the task and on managing the task in order to accommodate the students' needs, several preservice teachers had seen a lack of mathematical ability as a difficulty in developing tasks, and so felt they could not engage the students effectively in both the talk and the mathematics.

Recognising Students' Learning

Less than half the preservice teachers felt they had made an impact on the students' learning. Many of these comments related back to the preservice teachers' development of the tasks, with some preservice teachers commenting that they had selected tasks involving mathematics which the students were already familiar with, so there was no learning. Others felt their focus had been on developing the talk rather than on the mathematics, so again did not consider there was any learning.

Developing talk was our main focus, the activities were designed around boosting talk and not purely maths content.

Other preservice teachers noted how the students described mathematical ideas and explained their processes using mathematical language. For example, they noted how students developed their use of terminology in comparing the weight of different objects. This use of language was interpreted by some preservice teachers as students justifying their answers to the rest of the group, and so gaining confidence in reasoning. Alternatively other preservice teachers were unsure if an increase in use of language in describing mathematics ideas could be ascribed to learning as improved knowledge.

Some preservice teachers felt that the tasks may have consolidated mathematical knowledge, but the students had not learnt anything new. On the other hand, impact on learning was noted by one preservice teacher as the students worked with larger numbers, and so were encouraged to work above their "comfortable level," and to explain how they carried out "some quite complex maths" to the rest of the group. Another preservice teacher referred to an act of teaching in relation to right angles that he found necessary for the students to solve a problem. The preservice teacher described making a right angle, pointing to a corner and then asking the students to point to other right angles in the room. This preservice teacher saw this direct act of teaching as impacting on the students' learning as they had learnt something new. A further

preservice teacher commented that leaving the students to work through problems independently could help promote relational understanding, even if the reasoning was incorrect. For other preservice teachers, students who had been not been able to find a solution or had used mathematical thinking incorrectly were not seen to be learning.

Preservice teachers' responses in relation to impact on the students' learning suggested different interpretations. Whilst some gave specific examples suggesting new or increased knowledge, for example moving to more complex mathematics or direct acts of teaching, for many preservice teachers the tasks were seen to consolidate existing knowledge. Whilst the mathematics may not have been new to the students, some preservice teachers saw how students explained their thinking by drawing on prior knowledge. These preservice teachers appeared to link practice and consolidation to the notion of interthinking, and hence suggested an impact on learning. However, other preservice teachers saw that talk, in relation to practising and consolidating existing knowledge, did not suggest an impact on learning.

Value of the Experience to Future Teaching

Analysis of the comments in relation to perceived difficulties and opportunities suggested the preservice teachers had different perspectives in relation to the use of the didactic strategies, accommodation of tasks to student abilities, and the recognition of student learning in mathematics. Even so, all of the preservice teachers felt the experience had impacted on their professional development. The only negative criticism was that there was insufficient time, and that the preservice teachers would have liked to continue the experience. The focus on talk and collaboration within the microteaching experience was seen as valuable.

I have seen the importance of teaching and modelling talk in a micro teach environment. Seeing the benefits on a very small scale has made me much more aware of my use of talk in the classroom

Some preservice teachers appreciated how collaboration and talk could help develop understanding in mathematics and that they had a chance to see this "first hand." They noted how this had changed their perspectives.

I now believe that talking effectively can be a benefit to children's education.

One comment showed how the experience had moved the preservice teacher's view of mathematics, and that it was not just about right or wrong answers. Furthermore, this preservice teacher explained:

This experience has changed the way I want to teach mathematics. It has given me confidence to use this type of teaching and learning in maths lessons, rather than a more prescriptive approach.

Several preservice teachers commented that the experience had helped them target teaching for problem solving, and commented on practical management issues that could support collaboration, such as removing the need for students to record. For other preservice teachers, the experience had helped them notice how phrasing questions differently would encourage students to verbalise more.

It has raised my awareness of the value of asking the 'right' kind of questions.

Preservice teachers also commented on how the project had instilled in them the notion to sit back and observe students working rather than to "do the teaching", and furthermore, how this made assessment "quick and easy."

How important it is to sit back and reflect on how the children are working and listen to them. You can learn a lot about what they know and how they learn best.

However, several preservice teachers commented that they had found sitting back and observing very difficult.

Summary of Analysis of Questionnaire Responses

Analysis of the statements from the matrix queries suggested that, within the first three themes, the same phenomena could relate to different interpretations. What some preservice teachers had perceived as opportunities in supporting student talk and learning, others had perceived as difficulties. The need to continue the use of didactic strategies was realised, by some preservice teachers, as a key didactic strategy that impacted on the students' use of talk, whereas for others, continued use of didactic strategies suggested a lack of spontaneity and, hence, a lack of impact on use of talk. Focusing on both the talk and the mathematics in accommodating the task demands to the students was problematic for some preservice teachers. The mathematics had to be simple enough to encourage the talk. However, other preservice teachers recognised that, by focusing on the management of tasks to support talk, they could help students access more challenging mathematics.

A lack of recognition of impact on learning may have been related to problems in accommodating the tasks to the students, but there also seemed to be differences in recognising the students' learning. Whilst specific instances of learning had been reported when directly teaching a new idea, such as a right angle, or where students moved to more complex mathematics, the preservice teachers' recognition of learning varied. Could verbalisation and reasoning of mathematics already known to the students be seen as learning or was this consolidation? Could use of mathematics terminology be seen as students' understanding of the mathematics? Did incorrect reasoning suggest or show lack of understanding? These phenomena seemed to be interpreted differently.

Notwithstanding these different interpretations, all the preservice teachers who responded in this study indicated that the focus on talk in the microteaching experience, albeit over a short period time, had impacted on their professional development in some way. The preservice teachers appeared to see the potential of an alternative approach to teaching mathematics. In particular, they felt they had seen talk and collaboration 'first hand', they had practised questioning skills, and become more aware of the benefits of sitting back and observing students. However, for some the difficulties raised by this approach were seen as impediments in determining impact, for others the same difficulties became positive opportunities for furthering their teaching.

Preservice Teachers' Recounts of the Microteaching Experience

The themes were examined further in relation to three preservice teachers' written reflective recounts of the microteaching experience. The three examples were selected as they all suggested the preservice teachers had some success in developing tasks and in supporting the groups in collaborating and talking, but they also illustrated the different interpretations of the phenomena that have been considered. The preservice teachers' recounts have been abridged in order to be more succinct and to suit the length of this paper.

Lucy:

At the beginning of this project I realised that young children quite often just agree with each other to get a task done as quickly as possible. The aim therefore from week 2 was to encourage the children to ask each other questions and discuss possible answers. So we introduced a task where the children had to agree whether a mathematics statement was true or not. The ground rules worked as a prompt when the children were unsure what to say and meant less teacher

intervention was needed. Using these rules to model the appropriate talk for the mathematics problem solving enabled the children to put these skills into practice themselves. They were encouraged to talk to each other rather than aim the questions at the teacher. Choosing the mathematics problem-solving activities was difficult, as they had to be hard enough to challenge the children so that there was room for disagreement and discussion but not so difficult that they could not access the mathematics.

In the first week the children were not talking about the mathematics and appeared to be working individually. In week 2 there was evidence of talk, as there were more disagreements, and the children had to explain their reasoning, e.g. "Maybe three in a straight line? Katie, do you think it's good?" The last week was a turning point. The children were aiming questions at each other rather than the teacher. One student explained a division question using a bead string. He explained that 30 cannot be shared equally between 4 people but if it was 40 it could because it would be 10. The other children were listening intently and agreed.

I have learnt the importance of allowing children the opportunity to figure things out for themselves. By having the confidence to hand over control to children they can advance. The experience has taught me the importance of teaching appropriate group work as well as giving the opportunity to do so in an interactive and supportive way. By encouraging children with appropriate lessons and scaffolding group interaction throughout, children's collaborative learning and mathematical ability can improve.

Lucy reflected on how the prompts, as didactic tools, encouraged the students to work collaboratively and independently of her as a teacher. Lucy commented on scaffolding the use of talk throughout, suggesting that she saw the use of prompts as a necessary didactic strategy that should be continued. She seemed to realise the need to teach students how to collaborate. Lucy provided evidence of how the students' talk and their explanations to each other developed across the weeks. Furthermore, she commented how the students listened intently to another's explanation, indicating an element of interthinking.

Jake:

In week one the students were working on the problem: Three birds laid some eggs. Each bird laid an odd number of eggs. Altogether they laid 19 eggs. How many eggs did each bird lay? Find different ways to do it. The students did not talk or collaborate until the teacher intervened and reinforced collaboration and use of talk prompts. They then worked together to check that they had all of the combinations. Once the group thought they had finished, one pupil stopped and said "but there must be one more." This occurred because they had $6+4$ and $4+6$ twice, but $5+5$ only once, and the pupils thought $5+5$ should be placed twice. This led to a discussion between two pupils in deciding if $5+5$ and $5+5$ were the same combination. One pupil said "but $9+1$ is the same as $1+9$ and we have that twice." They concluded that they can be different but $5+5$ is the same.

In the second week we designed a task that required the pupils to crack the code to open a safe by making numbers using odd numbered Numicon pieces: Make 16 using four odd numbers; make 17 using five odd numbers; make 17 using four odd numbers. First the students demonstrated their positioning of the pieces "Well this goes here, see that's it." However with the impossible puzzle (make 17 using four odd numbers) one of the students understood that two odd numbers always made an even number, therefore, as they had four odd numbers, that would also make an even number. She explained it with the Numicon and demonstrated that "when it's an odd there is a bobble but look they will always be flat."

I found this experience really helpful at demonstrating to me how difficult it is to develop pupils' talk, and how hard it is to ensure that the questions you ask are appropriate for developing talk. Although I have read lots of articles in relation to appropriate questioning, I found it difficult to put this into practice. I noticed that the group collaborated better when they were reminded that they were supposed to be collaborating, however I feel it is only a success if the pupils collaborate instinctively, and obey the talking rules without needing reminding.

Jake also recognised the need to support the students in collaborating, but he made the point that a continued use of the prompts suggested a lack of impact on the students' talk, as their use of talk was not instinctive. Jake did, however, comment on how the experience had raised his awareness of the difficulty in asking questions and in relating his reading of literature to his practice. Furthermore, Jake outlined a task that built on the mathematics that the students had been working on previously with odd numbers, and gave an example of a student's generalisation with the Numicon, potentially suggesting he recognised interthinking.

Peter:

In the first week the children were set a challenge to find the number of people and dogs in a park with 30 legs. With counters for heads and sticks for legs, the group experimented to allocate all the legs to the heads. They did not talk in depth but preferred to demonstrate their intentions and gain approval. In the second week we gave a task 'Circle of Additions'. The children had some counters with the numbers 1 to 12 on them, which they had to place on the blank circles in the ring in order that each pair of counters totalled the given number that separated them. The task required several attempts to reach the one possible answer. The children found it tricky to express why one method had failed, preferring to rely on trial and error. They did explain why they put each individual counter in place, but when they failed to solve the problem they struggled.

In the last week we set the task 'Tiles and Patterns' which entailed covering two patterns with identical, irregular tiles; one with plane symmetry and the other with none. At one point, when working on the symmetrical pattern, a child was heard to say, 'It is the same as that. Instead of that way round, put it that way.' On the non-symmetrical pattern a child explained that a particular method would not work because it would leave a single grid square uncovered and they did not have a tile to fit. These are excellent examples of how a suitable problem can yield some effective dialogue and hopefully assist understanding of the matter in hand.

It has to be said that for all tasks, over the weeks, the children did seem to need a lot of encouragement to volunteer their ideas and reasoning. More often than not they jumped in, picking up whatever tiles or counters were available as soon as ideas occurred to them. They had to be reminded regularly that they shouldn't really pick up or remove any apparatus until all the group had agreed to what was being done. Usually they were able to explain what they were doing but it did need teasing out of them.

Peter reflected on how a suitable task could support talk and collaboration, but he gave little indication how the experience had impacted on his professional development. He commented that the students needed to be reminded, and that explanations needed to be teased out. Whilst Peter seemed to develop successful tasks, and his recount indicated that the students were sharing solutions, he referred to the students' use of trial and error and their struggles in finding solutions. Furthermore, he commented on the students' explanations as an opportunity to assist understanding "of the matter in hand." Peter may have been suggesting the mathematics was situated solely in the problem-solving task, rather than something that could be applied elsewhere.

The three preservice teachers noticed key aspects in relation to students' behaviours in working together and in how the tasks had supported the students' problem solving. They recounted how the students increased their use of explanations, and also recognised how prompts and guidance were needed to reinforce the students working together. Even so, their reactions to the experience in relation to students' learning and use of talk varied. In particular, the challenge of using the prompts throughout the teaching episodes had been taken as an opportunity by Lucy to consider future actions in her teaching, but had been seen as a difficulty and lack of impact by Jake and Peter. Furthermore, their reflections on the student learning varied. Whilst all three recounted how students gave explanations to each other, and hence potentially identified aspects of interthinking, their conviction of how this constituted learning

differed. Jake did not reflect on the learning of the students, even though they appeared to find a general rule regarding odd and even numbers. Peter saw that the explanations suggested finding a solution within the context of the problem. On the other hand, Lucy interpreted the students' explanations to each other as having the potential to improve learning and mathematical ability.

Discussion

Analysis of the preservice teachers' reflections, both in the responses to the questionnaire and in the reflective recounts, suggested that, overall, the experience had impacted on the preservice teachers' professional development in some way. Aarsal's (2015) study has also shown that the interactive nature of microteaching experiences can provide an opportunity to relate theory and practice to the real world of the classroom in a small-scale and focused way, and this study would seem to support the finding. All the preservice teachers seemed to have valued the experience, and so may have been sensitised to work with their students in an informed way. However, their reflections suggested that their sensitisation differed. For some preservice teachers there had been clear statements, both through the questionnaire and the recounts, that the experience had changed their beliefs in using talk as a teaching approach; and even that the experience had changed the way they wanted to teach mathematics. For others, it seemed that they were sensitised to a new approach, but that the experience had raised awareness of the difficulties in working this way. It also seems that, for some, the impact had been minimal in changing views or expectations in teaching.

The analysis identified not just what the preservice teachers attended to, but also how they reacted to what they attended to, and whether they were mindful to act differently. "At the heart of the matter of learning from experience is the person's attention. What is attended to, in what ways, and with what intention and disposition?" (Mason, 2010, p.27). The guidance for reflections as part of the microteaching experience had directed the preservice teachers' attention to the students' collaboration, talk, and learning in mathematics tasks, and in many cases the preservice teachers commented on the same phenomena. However, how they reacted to the phenomena varied. Whether they were mindful to act differently may have related to their intentions and dispositions in relation to what they attended to.

The illustration of the varied intentions and dispositions from the reflective recounts may go some way to explain the differing interpretations of the phenomena in the questionnaires. From her recount, Lucy reflected on the experience as an interactive way of developing her teaching. She seemed to have confidence in using the strategies, and intended to continue their use in her future practice. Jake revealed how he found that the transfer of theory into practice was not straightforward. Jake also seemed dismissive because the students did not collaborate instinctively. Nevertheless, he still seemed to aspire to develop his teaching skills. Peter also seemed dismissive of the students' explanations as they had needed to be teased out. Furthermore, Peter did not comment on how the experience changed his teaching, and one wonders if he interpreted the continued use of prompts as the students' difficulties in collaborating, rather than an aspect of his teaching that he aspired to change. So, whilst Lucy, Jake and Peter may have attended to the same phenomena, their intentions and dispositions varied, suggesting variations in the ways that they were mindful to act.

For some preservice teachers, the difficulties in developing collaboration and talk with young children were seen as obstacles in supporting students' talk and learning. Hence their reactions were that they had limited impact. For others, the difficulties were seen as opportunities and possibilities, and that, as teachers they could act differently, and so make an impact on the students' learning and behaviour. So were some preservice teachers mindful of different

desirable actions whereas others were not? Did this mean that some preservice teachers were able to imagine themselves acting differently in their future teaching (Mason & Davis, 2013)?

Verbal comments on the questionnaire suggested that some preservice teachers felt they had focused on talk and behaviour rather than on mathematics learning, whereas others felt that the students' talk had suggested an impact on learning. Erikson (2011) and Barnhart and van Es (2015) observed how novice teachers often focused on superficial features of classroom interactions, such as the actions and behaviour of the teaching in a classroom, rather than on the substantive nature of the students' thinking. If students behave as expected, then they must be learning. It is possible that the preservice teachers who suggested use of talk indicated an impact on learning may have been focusing on the behaviour of the students. The students were talking and collaborating as required (albeit with prompts to support this behaviour), and so must have been learning; that is, they were following the talk routines, so they were learning.

Nevertheless, Lucy, Jake, and Peter's reflective recounts did focus on the content of the mathematics. For Lucy, the students' explanation of 40 as a multiple of 4 was seen as effective in students' sharing ideas. Lucy may have been referring to interthinking as a way of learning through collaboration and talk. Jake noted the use of the Numicon by one student in explaining addition with odd numbers. Although he did not comment on this as a generalisation, his recount suggested the students were taking a step forward in their learning by building on existing knowledge. Peter, on the other hand, commented how a student's explanation demonstrated the solution of a specific problem that may not be applied elsewhere. Peter also commented that the students struggled with trial and error and were not able to see a solution, and so may have suggested that learning is attributed to finding a correct solution.

Whilst it is only possible to speculate the intentions behind the three preservice teachers' reflections, their recounts do raise questions regarding interpretations of learning in relation to talk and collaboration, which may go some way in explaining the responses of the other preservice teachers. For example, engaging in a pedagogy that balanced the focuses of both talk and learning was something that several of the preservice teachers had not felt successful in. Jake and Peter's reflections suggested they did not feel successful in establishing both talk and learning, whereas it seemed that Lucy did. Lucy saw the students' explanations as evidence of impact from the use of her prompts to encourage talk and collaboration. Peter and Jake also referred to the students' demonstrating and showing intentions, but they did not feel they had made an impact on the students' talk. The interpretations of student talk and collaboration in relation to the learning in the three preservice students' recounts may have reflected other preservice teachers' responses in the questionnaire. It is possible that other examples of students' statements that built on existing knowledge were seen as consolidation and not as learning. It is also possible that some preservice teachers noted student explanations in solving a particular problem, but did not see this as learning, as there was no evidence of applying the knowledge to other situations. Some preservice teachers may have felt that the inability to find a solution, or finding an incorrect solution, could not be attributed to learning.

These possible interpretations are presented to raise a further consideration regarding preservice teachers' noticing and intentions to act in contingent situations. The preservice teachers' reflections and responses cannot necessarily be dismissed as a lack of focus on the mathematics content. However, their possible interpretations suggested that there is much to discuss regarding what we mean by learning in mathematics. It would seem that these preservice teachers may have noticed the mathematics in the students' shared talk, but their interpretation of what this talk meant in relation to learning may have differed. The distinction between the students talking to share ideas and their learning may be further compounded by the issue that a focus on the students' talk was easier to determine than their learning in mathematics. What the students said in relation to each other, and whether they collaborated or not was easily

observable. Hence from a novice teachers' perspective, the focus on talk was more straightforward.

Griffin's (1989) famous epigram "Teaching takes place in time, learning takes place over time" (p. 12) is often quoted in texts on mathematics education. In regard to this epigram, how might the preservice teachers recognise learning in mathematics when reflecting on an episode of their teaching? In reflecting on pieces of teaching that take place in time, the identification of learning that may happen over a longer period, is not so obvious. Unless the preservice teachers were able to see an act of teaching in relation to an exact learning outcome that presented new knowledge to a student, then they may have found it difficult to determine what, if any, learning was happening. Whilst the preservice teachers planned a task in relation to a particular mathematics content (such as odd and even numbers or symmetry), a student's learning when solving a problem within a group may not be as obvious as the learning in the traditional student-teacher-content triad and the replacement format of classroom communication. This epigram may also relate to how the preservice teachers determined any impact on the use of talk during the experience. If the students had not acquired spontaneously a type of talk but continued to need prompts and reinforcement, then teaching for talk was still required, and the students had not learnt to talk and collaborate. In order to *know to*, rather than *know that*, the preservice teachers would need to notice changes in their students' talk and how these changes might relate to sense-making in mathematics. That is, to recognise connections between learning, talk, and collaboration over time.

Conclusion

The intentions of the study were to examine the preservice teachers' reflections on the contingent situations of a microteaching experience based on exploratory talk, in order to better understand preservice teachers' emerging awareness of teaching and learning in mathematics. The theory of noticing informed the framework for analysis in considering how the microteaching experience might have sensitised the preservice teachers to act differently. Responses and reflections of the preservice teachers suggested different interpretations of phenomena that emerged from the experience. These different interpretations may further indicate the complexity of managing contingent situations and of developing *knowing to* as an aspect of teacher knowledge in mathematics.

Whether the experience impacted on the preservice teachers' during their practice in their careers as beginning primary teachers cannot be determined from this study. Nevertheless, it seemed that all the preservice teachers valued the experience, and some indicated desires and aspirations to change the way they taught mathematics. Even so, many preservice teachers noted the difficulties they encountered, and these may have been seen as obstacles in moving from a more traditional pedagogy. As noted in the introduction, other studies have shown that preservice teachers return to traditional types of talk despite university-based courses encouraging alternative pedagogies (Jaworski, 2003; Fisher, 2011). The findings of this study question how much the return to traditional types of talk is due to the views of the preservice teachers, or how much this return masks the difficulties experienced by novice teachers to act differently, even though they may have aspirations to do so.

Notwithstanding the immediate difficulties some of the preservice teachers experienced in using questioning, meeting tasks to students' needs, encouraging talk, and supporting collaboration, it also seemed that *knowing to*, as an aspect of in-the-moment pedagogy, requires recognition of students' thinking and behaviour *in-the-moment*. In order to become sensitised and aware of one's teaching and, hence to act differently and appropriately in the future, this

recognition would need to relate to learning over time. If we view knowledge for teaching mathematics as *knowing-to* rather than *knowing-that*, then mathematical awareness in relation to *in-the-moment* pedagogy is not necessarily a straightforward act of seeing learning in relation to exact prescribed learning outcomes.

For preservice teachers, a return to traditional pedagogies in Brousseau's teacher-student-content triad may provide a clearer recognition of students' learning and behaviour. In explaining and modelling something that the student did not know before, the preservice teacher can see acts of teaching clearly, they can see it happening in time. If students solve problems through talk and collaboration, then the act of teaching is less clear, and, hence, seeing the learning may not be so obvious. As such, a return to traditional pedagogies might not only be related to preservice teachers' previous experiences of learning mathematics, the return might also relate to how a traditional pedagogy allows a clearer view of the act of teaching. Recognition of this tension would seem to have implications for preparing preservice teachers to teach in non-traditional ways and for developing awareness of student learning in contingent situations. As such, there is a need to explore what is meant by learning from a wider perspective and within different pedagogies. Questions could be raised with preservice teachers in terms of what they notice when students work mathematically in relation to learning, and how preservice teachers can interpret what they notice in order to act differently in the future.

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