Social Constructivism in the Classroom: From A Community of Learners to A Community of Teachers.

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This paper reports on a Head of a Mathematics Department (the author) in a Brisbane suburban High School and her attempts, over a two year period, to implement a new teaching program involving innovative curriculum resources and a new pedagogy into the first year of high school. The goal of the Head of Department was to support staff to create learning environments that followed a social constructivist philosophy. What was found was that there was a parallel process that occurred for the teachers. The teachers were learners and they needed a community of learners for support within which to reflect, learn and grow.

Introduction and Background

How students learn to think, reason, and problem solve mathematically informs teaching practice. Booker (1996) contends that it is a "commonly held belief among mathematics educators" (p. 381) that students learn mathematics by "the individual construction of ideas, processes and understandings" (p. 381). Students bring to the classroom knowledge and thinking that has proven successful for them in the past. These knowledges and thought patterns guide their replacement by new thinking and in this way, students can be seen to be "active meaning makers" (Booker, 1996, p. 382).

> Mathematical thinking is based not on the symbols that are used, but on the meaning on which they are based and come to represent. (Booker et al., 2004, p. 24)

Thus, a teacher's role is not to transmit "the" mathematical knowledge to the students but to assist in the reconstruction of particular ways of thinking. Selection of relevant models, materials, patterns will assist learners in constructing the "mathematical ways of knowing compatible with those of the wider society" (Cobb, Yackel, & Wood, 1992, p. 27) but are not enough as "meanings do not reside in words, actions and objects independently" (Booker, 2004, p.16). Students gain meaning through discussion and debate – speaking and hearing mathematics – with each other and with teachers. In this way "mathematics can be viewed as a social practice or a community project" (Cobb, Yackel, & Wood, 1992, p. 27) and, so, classroom environments need to be created that cultivate active and engaged discussion (Booker, 2004).

One mode of instruction to consider is the instructional game and it is the pedagogy used in the curriculum reform of this study. Gough (2000) defines a mathematics game as "something you play to learn or practise mathematics." Ainley (1990) refines this by distinguishing the effective game as being born out of and inherently relying on mathematical ideas and understanding in order to run. The research is overwhelmingly in favour of using instructional games in the mathematics classroom. Booker (2000, 2004) argues that instructional games provide an explicit vehicle for discussions about mathematical concepts in that, for play to proceed, a mathematical dialogue has to have occurred. This may happen in the traditional classroom described by the TIMSS (1999) video study (in Hiebert et al., 2003), with students working on sets of problems whilst seated near other students, but it is an accidental by-product, not a planned occurrence. It is a planned occurrence when the teacher uses instructional games in their teaching.

Randel, Morris, Wetzel, and Whitehill (1992) reviewed the literature and they present a powerful case for changing the mode of instruction in the mathematics class. They found that the use of games in teaching mathematics is superior to traditional instruction in terms of achievement, retention, and motivation for learning. For students using instructional games in the classroom, the literature shows an increase in achievement, improved retention of information, heightened motivation to learn, greater participation, increased opportunities to learn, more complete engagement in the task, greater interest, improved confidence, and more risk taking/problem solving (Booker, 2000; Booker, 2004; Booker et al., 2004; Gough, 2000; Onslow, 1990; Ortiz, 2003; Pearn & Merrifield 2004; Randel et al., 1992; Rowe, 2001; Schmidt, 1995). The benefits of positive cooperative social interactions are also well documented (Booker, 2000; Ortiz, 2003; Rowe, 2001). The positives for teachers focus on the benefits to students. Booker (2000) also mentions increased opportunities to communicate with students one on one while they play and varied assessment opportunities via observation of student interactions during the game.

Teachers need professional support to integrate such pedagogy into their teaching and it is this aspect of a curriculum reform that is reported on in this paper. A comprehensive investigation into curriculum reform efforts has been conducted by Wilson, Peterson, Ball, and Cohen (1996) and it provides direction for educators who are endeavouring to bring about change to the way mathematics is taught. After various attempts to reform the teaching of mathematics in classrooms, policy makers learned that teachers needed considerable time to reflect and share their experiences with the new materials and professional development became meaningful conversations about the reform journey from teachers' perspectives. It was this process that lead to change in these teachers' classrooms. They were able to learn from each other and rethink their underlying assumptions and belief systems of mathematics teaching and learning. The teachers were put in the position of learner and given respect around what it takes to embrace change.

In stark contrast, Wilson et al. (1996) describe the journey of a teacher who does not see the need to change her teaching practice even after three years of participating in reform activities. The style of the courses she attended did not afford the teacher with any opportunity for conversation about what she was thinking and her experiences or the opportunity to hear from her colleagues. She summarised that she hadn't learned anything from the professional development activities and that the assessment reforms shown to her were too much work. Wilson et al. (1996) eloquently describe the situation the teacher is in:

> In the trenches of teaching's dailiness, Mrs. B. constantly faces obstacles to deep change. To learn what she needs to in order to translate these reforms into realities, she needs ongoing support, careful attention, and lots of opportunities to think – and rethink – her assumptions and practices. Yet such opportunities have not been offered her. Her experiences and ideas have been neither invited nor challenged. And the reform effort is the worse off for it in her classroom. (p. 473)

Ball (1993) also contends that teachers' work structure and the "accepted norms of social discourse – in what educators talk with one another about and in what ways" (p. 396) – make opportunities for meaningful discussion around conceptual understandings of mathematics and pedagogical dilemmas to be extremely limited. A suggestion for improvement made by Ball is the creation of a professional community within which teachers discuss and reflect on teacher practice. She cites an example of videotaping her own lesson and the wealth of information and ideas that came to her about her own practice as she examined it. Finding an answer is not the emphasis as such but the provision of the opportunity for choice and reflection on future directions. Lampert (1994) agrees with Ball when she concludes that if teachers had more opportunities to meet and work as a group on their teaching practice then they would gain insight and understanding into what is needed to teach effectively for understanding.

A four year study of six cohorts of preservice teachers by Frykholm (2005) provides evidence that interacting with innovative curricular material can have an extensive effect on preservice teachers' content knowledge of mathematics and their ideas about what good teaching and learning looks like. The preservice teachers reported that the materials that were used in class challenged the way they thought about mathematics and, hence, created a realisation that there was more to mathematics than learned procedures. Teaching became more about concepts than algorithms for these preservice teachers and they reported a determination to teach mathematics themselves in a conceptual way. Frykholm argues that it was through the interaction with the innovative activities from the perspective of learner that was the "catalyst for growth" (p. 31) for these teachers. Thus he emphasises it is not enough to just discuss the pedagogy of the reform curriculum:

> Through the explorations of the materials, the students learned a great deal about how curriculum might be structured, how mathematical concepts build on one another, how students' ideas and intuitions can guide classroom discussions, and the important connection between assessment and instruction. (pp. 32-33)

In conclusion, Frykholm states that contrary to research findings that preservice teachers knowledge and beliefs about mathematics are "fairly rigid and resistant to change" the preservice teachers in his study significantly improved their content knowledge and meaningfully changed their beliefs around the teaching and learning of mathematics.

Other studies emphasise the enhancing effect on teachers' mathematical and pedagogical knowledge of creating a learning environment for teachers. Teachers working together in collaborative groups have been shown to make a difference to their own understandings of mathematics (Jeanpierre & Lewis, 2007; McDiarmid, 1990; Soto-Johnson, Liams, Hoffmeister, Boschmans, & Oberg, 2007) and to those of their students (Siemon, Breed, & Virgona, 2006).

A detailed description of the "typical" classroom environment that many mathematics teachers work and teach in reveals that it is complex and impacted on by many internal and external factors (Ball, 1999). Tomlinson (2000) concurs with Ball when she lists the seemingly unrelenting pressures on teachers of oversized classes, challenging schedules, paperwork, and consistent persistent demands from administration and the community. Lampert (1994) eloquently sums up the situation with "teaching is not about solving problems, it is about managing complexity ... (it) necessarily is about trying to manage a lot of conflicting goals" (p. 30).

In addition to an already complex and pressured situation a program of reform is to be implemented which required teachers to come to terms with several new ideas – new physical materials of the instructional games, new content, and a focus on teaching conceptually. This major step into the unknown creates a lot of anxiety in teachers and it may feel chaotic (Frykholm, 2005). Rowe (2001) reviews several studies incorporating instructional games and highlights the increased workload in preparation and management of resources, the lack of student writing of mathematics, and the increased noise levels in the classroom. Her own study using games in her teaching leads her to conclude that the sessions when the games were played were "hard work" (p. 14).

Method

The researcher views research as a learning experience not a confirmatory process and seeks to uncover the social nuances that occur in a school during a significant change. Lampert (2001) points out that research that examines a case of teaching in detail will "contribute to a conversation about the nature of the work schoolteachers do" (p. 7) because insight is gained into the many facets of daily teaching life. She contends that such research is important because "there are problems of teaching practice that are common across differences in schools, subjects and age groups" (p. 6) and, so, an analysis of one teaching situation can inform another.

The aim of the study reported on in this paper was to investigate a department of teachers in a high school setting as they implemented a new pedagogy and curriculum into their teaching practice. The details of what it took to implement the new program from the perspectives of the leader and teachers involved and how that shaped the future directions of the program in the school are the main sources of enquiry. In this way, this study followed the process of participatory action research as defined by Kemmis and McTaggert (2000).

Participants and Data Collection

The participants in this study were the Head of Department Mathematics (the author) and the teachers of Year 8 Mathematics (four in 2005 and six in 2006 with three of these teachers involved in both years).

The researcher collected primary data in various forms – firstly, researcher field notes of observations of teachers and students; secondly, teacher observations of themselves and the students; thirdly, journal writing by the researcher and the teachers; fourthly, minutes and field notes from weekly teacher meetings and regular teacher professional conversations; fifthly, teacher interviews.

Discussion

It is important to emphasise the position the teachers were in. They decided to put themselves in the position of learner whilst teaching a new curriculum with a new pedagogy. They didn't just interact with the innovative materials and new pedagogy as the Frykholm (2005) students had as university students, they immersed themselves in it by actively endeavouring to teach with it in their classrooms over a five week period. Each lesson involved teaching with instructional games utilising the teaching methods of Numeration ideas as espoused in Booker et al. (2004).

The teaching team, in 2005, decided to meet each week for at least one and a half hours after school hours. Professional development of the curriculum content and resources was the planned focus of these meetings. A shared understanding of what to teach and the management of resources was seen by the researcher and teachers to be essential to the success of a new teaching program. What resulted from these meetings was that the teachers were undergoing a parallel process to the students in the classroom. That is, because the teachers were learners they created a social constructivist environment within which to learn just as they were trying to achieve in the classroom.

A case study illustrating how the teachers discussed with each other in their weekly meetings and, thus, worked through an issue leading to an assessment reform is described. The discussion at the weekly meetings initially focused on content knowledge and operational matters but it gradually became dominated by teachers attempting to find a better way to cater for all the levels of learning that were evident in their classrooms. As a leader, the researcher had designed the games so they could be used in the following way. Each style of game was available at several levels of learning and, so, the lesson could be organised around a particular big idea such as linking language to symbols and then each group of students given a game to play at their level of readiness. For example, the recognition games (shown in Table 1) came in four levels in terms of the size of the numbers and, also, within 4 and 6 digit numbers there were three levels of concept.

Table 1

The Recognition Games

Game Name	Purpose of the game
Recognise Me – 4	4 digit numbers – place value name recognition
Who am I? – 4	4 digit numbers – place value name recognition with saying the number
Recognise Match – 4	4 digit numbers – place value name recognition with comparing numbers
Recognise Me – 6	6 digit numbers – place value name recognition
Who am I? – 6	6 digit numbers – place value name recognition with saying the number
Recognise Match – 6	6 digit numbers – place value name recognition with comparing numbers
Who am I? – 9	9 digit numbers – place value name recognition with reading 9 digit numbers from the symbols
Who am I? – 12	12 digit numbers – reading 12 digit numbers written in words and then writing the symbols

In theory these seemed achievable but in practice teachers were not doing it and the researcher, as classroom teacher, was not able to achieve this in her classroom. Observation of classrooms showed that the teachers were tending to use the games towards the end of the lesson as a replacement for the traditional textbook exercises. A typical lesson involved teaching the concepts via direct instruction from the front of the classroom at the whiteboard followed by whole class practice from the whiteboard. Then the students would work on the games. This highlights that providing teachers with the resources to achieve a desired teaching outcome is not enough to make it happen. Teachers had to work through the issues together and come to their own conclusions as to how to proceed.

The effect on the students was marked as those who could do the work from the whiteboard became bored with the games very quickly as they had already mastered the skills and were ready for new challenges. The students who had not grasped the new concepts did not interact well with the games either as they were not ready for the ones they had been given. Teachers reported increased behaviour management issues. The field notes of a weekly meeting highlight this:

> One teacher reported her class as saying: “Do we have to do this? Why are you punishing us?” She said that the rest of the lesson was spent copying “times tables” from the board and that there was silence – yippee.

Further evidence to support this can be found in the researcher’s diary entries:

> I was out of my comfort zone. We are all out of our comfort zone and this could be one of the reasons. The cohort’s behaviour across the school has erupted of the last week or two and this makes the classroom a challenging place at the best of times. Hence, it is a gut reaction to revert to what was always done. It’s my teaching from the board that’s not working. The games are good.

By the fifth week of the program the weekly meeting was characterised by spirited discussion, a sense of frustration and concern over the direction of the program. Various teaching strategies had been tried over the weeks including “enrichment” worksheets and problem solving yet the need to cater better to the students’ learning needs was a recurrent subject of debate.

Staff still wanted to continue to try to work better with the instructional games and provide a learning environment so that all students had the opportunity to extend their understandings (minutes). This is not unexpected according to Lampert (1994) and Ball (1993) who espouse the need to give teachers time to meaningfully reflect on their practice. The fact that the staff was so greatly concerned over trying to teach so as to meet multiple levels of learning needs simultaneously was a major paradigm shift from the traditional Year 8 lessons described by the TIMSS (1999) video study (in Hiebert et al., 2003).

The way forward was seen to be a formalisation of the differentiation process into the end of unit assessment (field notes). Students were required to submit a portfolio of work (refer Irvin & Booker, 2005). There were three difficulty levels of portfolio and each student was issued a personal list according to the progress of their learning as ascertained by screening tests (Booker, 2005) and class teacher observations. Incorporated into each portfolio were games to be played by students whilst a teacher witnessed them, two written assignments, and a written report. One assignment involved making an own designed universal board game. Its inclusion emphasised to the researcher the value the teachers had placed on the instructional games and highlighted to the students the importance of the game in mathematics learning.

Feedback at the next weekly meeting was much more positive and indicative of the change created by the introduction of the portfolio task. Once the students began working on their individual portfolios the teachers reported that the behaviour issues inside the classrooms significantly decreased. The staff noted (in interview) a sense that they were teaching the students and that the students liked having choice and the work set at their level of understanding. Observations of teachers' lessons and the researcher's own lessons indicated that there was much less teacher talk from the front of the class.

The curriculum program was taught again in 2006 and provides a comparison. Weekly meetings quickly discontinued in 2006 due to several contributing factors. Firstly, three of the six teachers had been on the 2005 team and they reported (in interview) that they felt very confident with what and how to teach as well as believing they could mentor the other three teachers new to the program on an as needed basis in the staffroom. Secondly, substantial lesson resources had been created the previous year to support teachers in their individual preparation. Thirdly, after the second meeting there was considerable dissension among teachers about the continuation of weekly meetings after school hours so as to cause considerable disharmony in the staffroom.

Even though formally arranged meetings were not occurring it is important to note that the researcher observed frequent discussion among the teachers of 2006. This was entirely left to the initiative of the teachers and provides a stark contrast to the weekly meetings of 2005. Two teachers' experience around collegial support provides insight.

Firstly, one teacher, new to the program, designed a menu of the instructional games for student use. This was along similar lines to the Portfolio Task with one important difference – the same menu was given to every student and every student had to demonstrate competent playing of every game on the list. In this way games appear to have been seen as akin to a set of exercises in a text – all to be done by all at the same time. Consequently, even though a number of students had demonstrated deep understanding of numeration ideas for up to six digit numbers (screening test, Booker, 2005), all had to play games such as "Who am I? – 6" which required players to state place names and read out loud six digit numbers. Observation of students indicated that the lessons were not engaging and that they complained loudly about how boring the games were. Feedback from the teacher interview was that the generic menus had not been such a good idea yet he was enthusiastic about using instructional games in the future.

Secondly, another teacher new to the program in 2006 noted, at interview, that she had never understood why the weekly meetings had been cancelled and, as a beginning teacher, had felt a bit unsupported and in need of some collegial help with pedagogical and mathematical matters. This teacher's desk was in a different staffroom which meant that she had had to rely on corridor conversations in the classroom block if she had happened to encounter one of the other teachers of Year 8 or made a special visit to the mathematics staffroom which she found difficult to find time to do. This does highlight the day to day busyness of teaching affecting the teachers that the literature describes (Ball, 1999; Lampert, 1994; Ma, 1999; Tomlinson, 2000; Wilson et al., 1996). Neither teacher had been a part of the discussions and experiences in 2005 nor been regularly included in the informal staffroom professional conversations in 2006 (researcher observations). These two teachers can be seen to have operated in isolation of the teaching team.

Conclusions

Attempts to implement a curriculum and pedagogical reform into a suburban high school by a Head of Department can be seen to have been successful. The Program was taught in 2007 and 2008. The pedagogy of instructional games has been incorporated into the way mathematics is taught at the school – they are central to units in Year 8 Numeration, Year 10 financial literacy and number, Year 12 prevocational mathematics and Year 9 Algebra. Teachers have made games involving multiplication facts, operations with negative integers, chance and data, and algebra. Another teacher has designed a "make a game" assignment in Science and students have made games for assessment in other subjects of their own initiative.

The Head of Department (the author) found that the learning process for teachers seemed to be aligned with social constructivist theories of learning. That is, teachers needed an environment where they could express their thinking and listen to others' understandings to compare with their own and coincidentally this was the environment they were trying to create for their students in their classrooms. The formalised weekly meetings of 2005 were more effective than the informal professional conversations of 2006 as staff had to be in the right place at the right time to be included. Some staff were left expressing a need for more support. As a result, the weekly meetings were re-established in 2007 and continue in 2008.

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