Experiences of Learning and Teaching Mathematics: Using Activity Theory to Understand Tensions in Practice

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This paper originates from a larger qualitative study exploring how teachers incorporate the affective domain into the primary mathematics classroom. This paper analyses teacher's experiences of mathematics and explores, using activity theory, how these experiences impact their teaching. An important factor to emerge from the data was teacher's own experiences learning mathematics and how this shaped their mathematical identity.

This paper is part of a larger qualitative study focusing on how teachers incorporate the affective domain into the primary mathematics classroom. The affective domain is an ambiguous construct but is commonly defined as a broad term encompassing feelings, emotions, attitudes and values that are attached to an idea, subject or object (Leder & Forgasz, 2006). Researchers suggest the affective domain is ever present in the classroom but often an incidental accompaniment to the mathematical learning (Goldin, 2000). Researchers also state that the affective domain is critically important in all teaching and learning but especially in mathematics (Evans, 2006; Hannula, 2006; Leder & Forgasz, 2006; McLeod, 1992; Schuck & Grootenboer, 2004).

This paper focuses on two participants and their experiences in teaching and learning mathematics. Participants' experiences are the focal point because over recent years there has been an increasing focus on teachers and their classroom practice (English, 2008). This focus is important because teacher's personal beliefs, attitudes, theories and experiences have a pivotal role, one which is described as "one of the most important influences on learning" (Zevenbergen et al., 2004, p.6). Therefore, teacher experiences and perceptions about mathematics are important to understand and analyse when focusing on pedagogy. English (2008, p. 6), even state that more research is needed into "how and what teachers learn from experience". This article discusses how identities and experiences have shaped pedagogical decisions as it "provides a way to connect cognitive, affective, social and cultural issues" (Ponte & Chapman, 2008, p. 243).

The Research Approach

This qualitative research adopted a critical ethnographic case study approach and involved five teachers located at "Hillsview Primary School" in Adelaide. The staff at Hillsview Primary School (referred to as Hillsview) identified the need for more discussion and collaboration as teaching is often an isolating profession (Fullan, 1997), so a Professional Learning Group (PLG) was established in partnership with the participants and the school. A PLG is a process of collective and collaborative learning within a group of people "who share a concern or passion for something they do and learn how to do it better as they interact regularly" (Wenger, 2004). The PLG was a safe and supportive environment which gave the participants many opportunities to critically engage with current literature and to develop and reflect on new teaching strategies to incorporate the affective domain. Along with a PLG, three individual interviews, reflective journals, and classroom observations combined to produce rich and detailed data. The rich qualitative data was analysed using Activity Theory (AT).

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Broadly defined, Activity Theory is a cross-disciplinary framework and a descriptive tool for understanding, analysing and explaining different forms of human activity (Sannino, Daniels, & Gutierrez, 2009). This framework "transcends the dichotomies of micro- and macro-, mental and material, observation and intervention in analysis and redesign of work" (Engeström, 2000, p. 960). The main unit of analysis is the activity system. A second generation system (Cole & Engeström, 1993) is used in this research and is referred to in discussions concerning Alice and Nick.

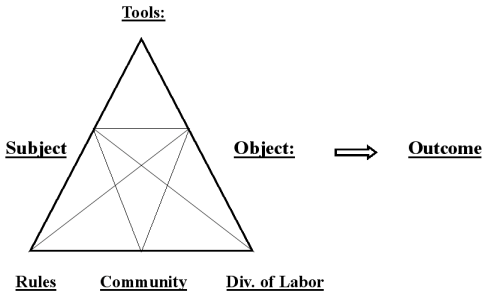

Figure 1. Second Generation Activity System (Cole & Engeström, 1993).

Activity Theory highlights the subject, the object of the action and the tools used within the action. This theoretical lens also focuses on the rules, division of labour and the community that guides and shapes the action and the outcome (as illustrated in Figure 1). The subject is the individual and/or group outworking the action and being impacted by or influencing the tools and the object. The object of the action refers to the aim of the activity system that is reached through the subject using the mediating tools and processes, concepts and/or mechanisms to achieve an object. The rules are the explicit and implicit rules and norms that guide and restrict the activity, the division of labour explains the break down of power and tasks within the activity system, whilst the community is the social context in which the subjects belong. These three things facilitate and constrain the development of action. Finally, the outcome describes the end result from investigating the activity system (Engeström, 1999, 2003; Miettinen, 1999). The nodes of the activity system are italicised in discussions pertaining to Alice and Nick, referring the reader back to the activity system. In activity systems "equilibrium is an exception and tensions, disturbances, and local innovations are the rule and the engine of change" (Cole & Engeström, 1993, p. 8). Tensions and disturbances were created as the participants wrestled with incorporating the affective domain into their mathematics classroom.

Context of the Study

Hillsview Primary School was selected from numerous other schools as they had a detailed strategic plan, which aligned with the purpose of the study and they also had many experienced teachers who were willing to be involved and passionate about mathematics. The Year 3-5 teachers from Hillsview were invited to participate because of the well-documented 'slump' in mathematics that can occur within these year levels (Luke, et al., 2002). The results of two participants are explored in this article.

Alice

Alice has been a teacher for 29 years. During this time she has taught in many different school settings both in the country and metropolitan areas. At Hillsview, Alice is a contract teacher who works three days a week teaching Year 5. Alice shares the teaching load with the Deputy Principal, Nick. As a child, Alice remembers mathematics as something she "really, really hated" (Int.1). She recalls being perceived by her teacher, family and other classmates as "not being very good at maths" (Int.1). Despite these negative experiences, she learned to persevere and continued in mathematics to Year 11 and Year 12. Alice explains: "I did struggle through it but I could see it was a necessity" (Int.1). She recalls having no hands-on materials to help her grasp concepts and it was purely a numbers and a mental discipline – something that "just wasn't meant to be enjoyable" (Int.1). Alice's teaching style focuses on strong relationships and on having fun – characteristics that were never present in her mathematics classroom growing up!

Nick

Nick's diverse teaching career has spanned over three decades. He has taught most year levels at some time or another and he has held various positions and leadership roles at the District level. His leadership style focuses on strong relationships and humour and he provides a high level of pastoral care to staff, students and parents when appropriate. Nick is Deputy Principal for three days of the week and teaches Year 5 for the other two days. Nick was always very fond of mathematics as a child and today he still "loves maths" (Int.1) He lived on a farm and grew up with mathematics being a natural part of his everyday life. In his first interview, he reminisced from his childhood, about counting turkeys they were to sell at market, and calculating their weights. Nick explains: "I loved mentally doing maths… I have always loved it and generally [I have] done really, really well" (N, Int.1). Nick is passionate about mathematics and his passion reflects in his deep knowledge, skill and application of this subject.

Results

Alice and Nick's activity systems and tensions are explored and compared. In particular attention is drawn to participants teaching experiences, learning experiences and their teaching pedagogy in the mathematics classroom. In the following discussion AT is used to describe how teacher experiences cause tensions within the activity system and how they may give rise to pedagogical decisions and changes.

Alice's Activity System

Alice's own experiences in mathematics have significantly shaped her beliefs about teaching and learning. Alice is passionate about making mathematics enjoyable and for students learning to be life-long. In her classroom, there is a lot of group work, discussion and use of hands-on learning and visual aids. The heartbeat of Alice's classroom is based on strong relationships, humour and encouragement. The students are encouraged to try hard at maths even if they are not always successful. She has established a classroom culture where trying and doing your best is the most important thing. She makes time for all students – especially the ones who struggle in mathematics. Within her activity system there are two tensions that significantly shaped her teaching pedagogy.

Tension within the subject. Alice's negative experiences as a learner of mathematics have shaped her significantly, resulting in a lack of confidence in her mathematics teaching. Alice desires to teach students to take risks, enjoy mathematics and to deeply learn mathematics (object) but she is aware of the gaps in her own skills and ability in mathematics. This causes a tension within the subject as she desires for mathematics to be fun and enjoyable but she has very few enjoyable experiences of mathematics herself, to draw upon. The following extract from Interview 2 illustrates the tension within the subject of Alice's activity system:

> Maths is not my forte, it never was … I certainly don't have self confidence. I guess I question what I do 90% of the time … I think you can question too much and I guess the personality trait for me is that I question what I do all the time because I don't fully believe that its quite good enough, there must be another way or something else must work better than what I've been doing but I do now that I'm good at what I do. (Alice, Int. 2)

This tension opened a significant doorway into past experiences. Alice's honesty encouraged others in the PLG to be honest about their experiences too. These negative experiences resulted in Alice lacking some confidence in teaching mathematical concepts. Interview's, PLG discussions and classroom observations made it evident that this was an important issue to deal with and discuss before moving onto new or different pedagogy in mathematics.

Tensions between subject and community. Due to Alice's lack of confidence, she is driven to develop and discuss useful classroom strategies. Alice reflected during her final interview that she favours sharing teaching practice and practical resources (tools) within the Professional Learning Group rather than philosophical discussions. Alice, a teacher who had negative experiences in mathematics as a learner and who questions her teaching practice, desires strategies that have been tried by others, have worked in others classroom. Others in the PLG (community) were more advanced from having wider community experiences within the field of education and were ready to move past the practicalities of teaching. Such participants valued deep philosophical discussions upon which teaching and teaching strategies are based. The following extract from Interview 3 explains the tension developed within Alice's activity system as the various motives of other participants came to light during the meetings:

> Let's share the practical ideas that actually work, and put that in a toolbox and you know, move it on. There are some in the group who like the philosophical discussions, and they are really interesting, and yes they're the basis of how we learn and all the rest of it, but I want the practical stuff, that's what I want to come out with, is the practical stuff, but that's a personal comment, you know, and that's in no way a slight on anybody else. (Alice, Int. 3)

The tensions present in Alice's activity system related to her experiences, perceptions and knowledge. No resolutions were reached, but the PLG provided a safe and supportive environment to share these experiences and tensions, leaving Alice with strategies to work towards resolutions.

Nick's Activity System

Nick's activity system is founded on two beliefs. Firstly, he believes that mathematics is everywhere and connects to all aspects of students' lives. Secondly, he believes that wellbeing is central to all learning. Nick is driven by his *outcome* or endeavour to incorporate the affective domain into mathematics and his *object* is to teach so that students are empowered, life-long learners, and work like mathematicians. Nick favours

tools such as student and self reflection, strong and safe relationships within the classroom and connecting mathematics to all learning to act on this *object*. His underlying motive for teaching maths with these goals is that the knowledge and the skills student learn, will benefit them later on in life and prepare them for Year 6. Within this activity system there are various tensions that have developed over the course of the study and two key tensions are emphasised.

Tension between community and object. Perhaps one of the most difficult and immediate tensions Nick had to face was between the student (community) perceptions of mathematics and the object of creating numerate mathematicians. This tension was revealed in the first interview with Nick who suggests that he has been aware of this tension for a significant period of time. From the beginning of the study it was evident through Nick's first interview that he is passionate about teaching mathematics in such a way that students learn that mathematics is everywhere. Nick explained, however, that this way of teaching mathematics seems to be problematic for some students, as they believe that mathematics is simply adding and subtracting and working from a textbook. The students in his classroom often prefer conventional mathematics where they can add and subtract and demonstrate their speed at doing so, but Nick wants their skills to be further developed so they can apply the mathematical knowledge to real life situations. The following extract from Interview 1 begins to suggest this tension between the students in the community and the object of numerate mathematicians:

> So there's a batch of kids where it doesn't work if they've got to think to hard because they want it to be easy – they want to show off their amazing ability to be fast and smart. What they can't do is apply very well … In other words if it's not an exercise on the board then they don't do so well. (Nick, Int.1).

Nick was raised with mathematics as a common language used to describe the farm, the world he lived in. The students in his class were not used to mathematics being a language – instead they perceived it as a school subject that required paper and pen and lots of mental computations. This was a constant tension throughout the duration of the study. Another tension was between the rules of the system and Nick's object.

Tension between the rules and object. In Nick's final interview he reflected on his priorities within teaching mathematics. One priority early in his career was to cover the mathematics curriculum (*rules*), and produce good academic results for all students in this learning area. Nick is obviously expected to teach the whole curriculum and thus he felt restricted in choice of alternate pedagogy. Nick believes that the process of learning maths is more important than correct answers. The thing that is valued is the process of learning and the process of thinking like a mathematician, where maths is viewed as a cognitive and affective entity. He struggled to find strategies teaching the expected curriculum and simultaneously developing mathematics lovers. The following extract from Interview 3 begins to suggest a tension between the curriculum, the need for students producing good mathematics results and the development of mathematically literate and autonomous students:

> I think I was too driven by success and achievement, and the content, rather than the process. So, that's my passion, and then, I guess I apply the same sort of thinking and process in my classroom. And I do get frustrated in the classroom, because sometimes the curriculum's so big. (Nick, Int.3)

According to Nick, the curriculum (*rules*) is big and sometimes frustrating, but he had decided to focus on the process of learning mathematics rather than focusing on the size of the curriculum. His leadership experience tells him that curriculum is important and must

be taught and but his many years of teaching experience indicate that authentic learning is equally important. This tension caused Nick to reflect on the opposing views of curriculum versus numerate students (*object*) and from this reflection came a significant resolution.

Resolution. The *object* of Nick's activity system was to teach students (*community*) to think and work like mathematicians, but he was aware that their perceptions of maths would hinder this. This primary tension gave rise to new ways of teaching. Nick resolved this primary tension by creating a whole school initiative called a 'Math-a-thon'. Nick was aware that perceptions of mathematics were very narrow and limited. He was also aware that the curriculum (*rules*) was too large to adequately teach well within the school year. He designed a maths trail for all students and encouraged parent and community participation. It was a huge event, which made maths fun – although Nick reported that many of the students still complained that they had to 'think too hard'. Nick believed the Math-a-thon helped change student and parent perceptions of maths and impacted the student's affective domains – their feelings about maths. Nick also felt that the Math-a-thon integrated the curriculum, thus making it more manageable. It took the focus away from achievement, although that was still measured, and emphasised the process of using the mathematical knowledge students had. This event only lasted two days but the learning that occurred in the months leading up to the event integrated the curriculum and placed mathematics and numeracy at the forefront of the school day. The tensions within Nick's activity system gave rise to whole school change in the teaching and learning of mathematics.

Discussion and Conclusion

From examining the activity systems of the two participants it is clear that background experiences, attitudes and beliefs are strongly influential in shaping tensions and in determining their responses to such disturbances in their activity systems. Alice's negative experiences as a learner of mathematics lead to significant subject and community tensions, which she addressed through openness and discussions with others in the PLG. Her tensions were limited at a classroom level, as she wrestled with her day-to-day teaching of mathematics. Nick's broader leadership perspective and confidence in mathematics lead to tensions and resolutions beyond the everyday classroom pedagogical issues. As Alice deals with the primary tensions and grows in confidence she may be liberated to address higher level concerns outside of her immediate classroom.

This case study comparison of two teachers has many implications for mathematics education and research. Firstly, it is imperative that time and space is given for teachers to reflect on their own mathematical identity and how this is shaping their teaching. Secondly, it is important that time is given to teachers to discuss, reflect and explore pedagogies.

In conclusion, the findings of this study contribute to wider discussions on teacher education and development and reinforce the understanding that teachers own identity and experiences prior to entering the classroom are significant and must be given attention by educators and the wider research community within mathematics education.

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