A SOCIOCULTURAL ANALYSIS OF LEARNING TO TEACH

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This paper addresses the question of how teachers learn from experience during their pre-service course and early years of teaching. It outlines a theoretical framework that may help us better understand how teachers' professional identities emerge in practice. The framework adapts Vygotsky's Zone of Proximal Development, and Valsiner's Zone of Free Movement and Zone of Promoted Action, to the field of teacher education. The framework is used to analyse the pre-service and initial professional experiences of a novice secondary mathematics teacher in integrating computer and graphics calculator technologies into his classroom practice.

A challenge for mathematics teacher education is to understand how teachers learn from their experiences in different contexts – especially when their own schooling, university pre-service program and practicum sessions, and initial professional experiences can produce conflicting images of mathematics teaching. This challenge is sometimes associated with the perceived gap between the decontextualised knowledge provided by university-based teacher education and the practical realities of classroom teaching. As a result, novice teachers can find it difficult to implement innovative approaches they may have experienced during their pre-service program when they enter the more conservative setting of the school (Loughran, Mitchell, Neale & Toussaint, 2001). Clearly, a coherent theory of teacher learning is needed to account for the influence of these varied experiences.

Rather than appealing to cognitive theories that treat learning as an internal mental process, some researchers have begun to draw on situative or sociocultural perspectives in proposing that teachers' learning is better understood as increasing participation in socially organised practices that develop their professional identities (Ensor, 2001; Lerman, 2001; Peressini, Borko, Romagnano, Knuth & Willis, 2004). Identity can be said to emerge in practice, but identity also affects the ways in which a teacher interprets and analyses problems of practice. In the process of making instructional decisions and reconciling competing priorities, teachers construct their professional identities as individuals-acting-in-context.

The purpose of this paper is to outline a sociocultural framework for studying how teachers learn from experience in complex social settings, and how this shapes their professional identities. A case study from a three year longitudinal project is presented to demonstrate how the framework can guide analysis of pre-service and initial professional experiences of secondary school mathematics teachers.

THEORETICAL FRAMEWORK

Studies of teacher socialisation from a functionalist perspective typically identify influences such as the beliefs that students bring to the pre-service course from their

2005. In Chick, H. L. & Vincent, J. L. (Eds.). *Proceedings of the 29th Conference of the International Group for the Psychology of Mathematics Education*, Vol. 3, pp. 49-56. Melbourne: PME.

own schooling, and the classroom practices they observe and experience as novice teachers (Brown & Borko, 1992). Such approaches view teachers as being passively moulded by external forces to fit the existing culture of schools – thus producing the common explanation for why many beginning teachers give up their innovative ideas in the struggle to survive and conform to institutional norms of traditional practices. However, an alternative, sociocultural, perspective proposes that any examination of teachers' learning and socialisation needs to consider the "person-in-practice-in-person" (Lerman, 2000, p. 28), a unit of analysis that allows us to shift our analytical focus between the individual and the social.

The theoretical framework explored in this paper adopts a neo-Vygotskian approach, extending the concept of the Zone of Proximal Development (ZPD) to incorporate the social setting and the goals and actions of the participants. Vygotsky (1978) defined the ZPD as the distance between a child's independent problem solving capability and the higher level of performance that can be achieved with expert guidance. In a teacher education context, the ZPD can be thought of as a symbolic space where the novice teacher's pedagogical knowledge and skills are developing under the guidance of more experienced people. However, this gap between present and potential ability is not the only factor influencing development. Valsiner (1997) proposed two further zones to account for development in the context of children's relationships with the physical environment and other human beings: the Zone of Free Movement (ZFM), representing environmental constraints that limit freedom of action and thought; and the Zone of Promoted Action (ZPA), a set of activities offered by adults and oriented towards promotion of new skills.

Blanton, Westbrook and Carter (2001) have employed Valsiner's zone theory to examine the development of novice mathematics teachers. Their approach involved analysing patterns of classroom discourse to uncover contradictions between the ZFM organised by the pre-service teacher (what did the teacher *allow*?) and the ZPA she established for her students (what did the teacher *promote*?). The focus is on *students'* learning: the ZFM represents the classroom and the ZPA the activities offered by the teacher. The research reported here extends this study by applying Valsiner's ideas to *teachers'* learning by considering their social and institutional contexts and how these environments enable or constrain teaching actions.

For pre-service or beginning teachers, elements of the Zone of Free Movement might include their students (behaviour, motivation, perceived abilities), curriculum and assessment requirements, and the availability of teaching resources. While the ZFM suggests which teaching actions are *possible*, the Zone of Promoted Action (ZPA) represents the efforts of a university-based teacher educator, school-based supervising teacher, or more experienced teaching colleague to *promote* particular teaching skills or approaches. It is important that the ZPA be within the novice teacher's ZFM, and is also consistent with their ZPD; that is, the actions promoted must be within the novice's reach if development of their identity as a teacher is to occur. This is represented diagrammatically in Figure 1.

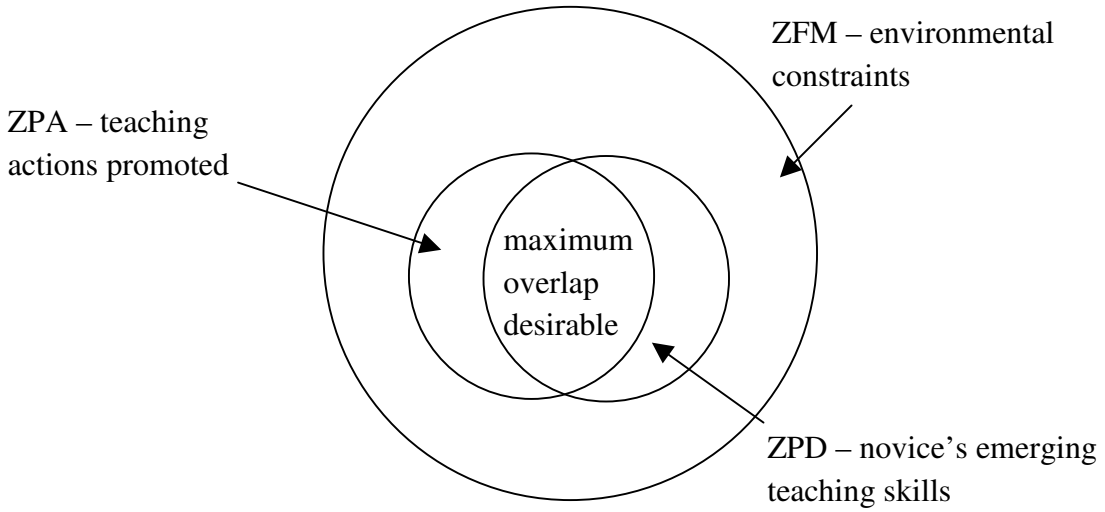

Figure 1: Relationships between the ZFM, ZPA and ZPD for novice teachers

Additionally, pre-service teachers develop under the influence of two ZPAs – one provided by their university program, the other by their supervising teacher(s) during the practicum – which do not necessarily coincide. These three zones constitute a system that can account for the dynamic relationships between opportunities and constraints of the teaching environment, the teaching actions specifically promoted, and the development of the novice teacher's pedagogical identity.

BACKGROUND TO THE STUDY

This research study is investigating the transition from pre-service to beginning teaching of secondary school mathematics. A major aim is to identify factors that influence how beginning teachers who have graduated from a technology-rich pre-service program integrate computer and graphics calculator technologies into their practice. This focus on relationships between technology and pedagogy in pre-service education and the early years of teaching provides rich opportunities to analyse teachers' learning and development in terms of identity formation. How do beginning teachers justify and enact decisions about using technology in their classrooms? How do they negotiate potential contradictions between their own knowledge and beliefs about the role of technology in mathematics education and the knowledge and beliefs of their colleagues? How do they interpret aspects of their teaching environments that support or inhibit their use of technology?

Questions such as these, when framed within a sociocultural perspective, may help us re-interpret and extend existing research findings on mathematics teachers' use of technology. This research has identified a range of factors influencing uptake and implementation, including: skill and previous experience in using technology; time and opportunities to learn; access to hardware and software; availability of appropriate teaching materials; technical support; support from colleagues; curriculum and assessment requirements; knowledge of how to integrate technology

into mathematics teaching; and beliefs about mathematics and how it is learned (Fine & Fleener, 1994; Manoucherhri, 1999). In terms of the theoretical framework outlined earlier, these different types of knowledge and experience represent elements of a teacher's ZPD, ZFM, and ZPA. However, previous research has not necessarily considered possible relationships between the setting, actions and beliefs, and how these relationships might change over time or across school contexts.

METHOD

This longitudinal study involves three successive cohorts of pre-service secondary mathematics teachers. In the final year of their pre-service program participants complete an integrated mathematics methods course, and two 7 week blocks of supervised practice teaching in schools. I design and teach the methods course so that students experience regular and intensive use of graphics calculators, computer software, and Internet applications (see Goos, in press). Thus the course offers a teaching repertoire, or ZPA, that emphasises technology as a pedagogical resource.

Case studies of individual pre-service teachers were conducted to capture developmental snapshots of experience during the second block of practice teaching (August) and again towards the end of their first and second years of full-time teaching (October/November). Six cases were selected in each year of the study to sample a range of different practicum school settings, including technology-rich and technology-poor government and independent schools in capital city and regional locations. These participants were chosen because of the interest and skills they demonstrated in using technology resources in mathematics teaching. Because they were eager to use technology, it was anticipated that their experiences in schools could provide insights into how they dealt with obstacles or took advantage of opportunities in incorporating technology into their pedagogical repertoire.

I visited these teachers in their schools at the times described above. The school visits involved lesson observations, collection of teaching materials and audio-taped interviews. Two types of interviews sought information on factors shaping the formation of beginning teachers' professional identities. A Post-lesson Interview was carried out immediately after the observed lesson to assist teachers to reflect on pedagogical beliefs that influenced lesson goals and methods. A more general Technology Interview was also conducted to discover what opportunities participants had to use technology in mathematics lessons, their perceptions of constraints and opportunities affecting their use of technology, and their views on the influence of technology on mathematics curricula, learning, teaching and assessment. (A full description of interview methods is provided in Goos, in press.)

All interviews were transcribed to facilitate analysis. Participants' responses to the interview questions were categorised as representing elements of their ZPDs, ZFMs, and ZPAs. As the zones themselves are abstractions, this analytical process focused on the particular circumstances under which zones were "filled in" with specific people, actions, places, and meanings.

CASE STUDY ANALYSIS

An analysis of one case study is presented below. This participant (Adam) completed the pre-service course in 2003 and entered his first year of teaching in 2004.

Adam's Experience as a Pre-Service Teacher

Adam's practicum placement was in a large suburban school where he was assigned to teach a range of junior and senior secondary mathematics classes under the supervision of the Head of the Mathematics Department. The school had recently received funding from the State government to establish a Centre of Excellence in Mathematics, Science and Technology, and had used this money to refurbish classrooms in the Mathematics Department and buy resources such as graphics calculators, data logging equipment, and software. Every mathematics classroom was equipped with twelve computers, a ceiling mounted data projector, and a TV monitor for projecting graphics calculator screen output. All students in the final two years of secondary school (Grades 11 and 12) had continuous personal access to a TI-83 PLUS graphics calculator via the school's hire scheme, and there were also sufficient class sets of these calculators for use by other classes (Grades 8-10). Some of these changes had been made in response to new senior mathematics syllabuses that now mandated the use of computers or graphics calculators in teaching and assessment programs. Thus the school and curriculum environment offered a Zone of Free Movement that afforded the integration of technology into mathematics teaching.

Adam had previously worked as a software designer and was a very confident user of computers and the Internet. Although he had not used a graphics calculator before starting the pre-service course, he quickly became familiar with its capabilities and took every opportunity to incorporate this and other technologies into his mathematics lessons, with the encouragement of his Supervising Teacher. For example, in the lesson I observed he used the graphics calculator's *ProbSim* program to introduce Grade 8 (13 year old) students to ideas about chance and frequency distributions via a dice rolling simulation where the outcomes were displayed as a histogram. In theoretical terms, then, the supervisory ZPA was consistent with that offered by the university course and also with the ZPD that defined the direction in which Adam wished to develop as a teacher. However, when interviewed Adam wondered how he could prevent students from becoming dependent on the technology – they might simply "punch it into their calculator and get an answer straight away" – and this might rob them of some important learning experiences. He acknowledged that his concern probably stemmed from the fact that he had only ever used technology in his teaching, or observed its use by other teachers, as a tool for saving time in plotting graphs and performing complicated calculations, or for checking work done first by hand, and he speculated that teaching styles would need to change to incorporate technology in new ways that enhanced students' learning of mathematical concepts. Nevertheless it seemed that Adam's professional identity was emerging in a context similar to the "ideal" situation depicted in Figure 1.

Adam's Experience as a Beginning Teacher

After graduation Adam was employed by the same school where he had completed his practicum. As the school environment (ZFM) and mathematics teaching staff (ZPA) were unchanged, one might predict that Adam would have experienced a seamless transition from pre-service to beginning teacher; yet I found that this was not the case when I visited him there towards the end of his first year of teaching.

I observed him teach a Grade 11 class about the effects of the constants a, b, and c on the graph of the absolute value function $y = a|x + b| + c$. The students first predicted what the graph of $y = |x|$ would look like, and then used their graphics calculators to investigate how the shape of the graph changed with different values of a, b, and c. Although Adam clearly had specific goals in mind, the lesson was driven by the students' questions and conjectures rather than a predetermined step-by-step plan. For example, at the start of the lesson one student noticed that the graph of $y = |x|$ involved a reflection in the y-axis and she asked how to "mirror" this graph in the x-axis. Immediately another student suggested graphing $y = -|x|$, and the teacher followed this lead by encouraging the class to investigate the shape of the graph of $y = a|x|$ and propose a general statement about their findings.

After the lesson Adam explained that he had developed a much more flexible teaching approach:

> I had a rough plan and we kind of went all over the place because we found different things, but I think that's better anyway. Because the kids are getting excited by it and they're using their calculators to help them learn.

Instead of viewing technology purely as a tool for performing tasks that would otherwise, or sometimes also, be done by hand, Adam now maintained that the role of technology was "to help you [i.e., students] get smarter" by giving students access to different kinds of tasks that build mathematical understanding, especially tasks that involve modelling real world situations. Here he claimed to have been influenced by the university pre-service course and the highly experienced mathematics teacher who was the Director of the school's Centre of Excellence project described earlier.

These observations suggest that Adam's potential for development – the ZPD representing his beliefs about teaching, learning and the role of technology, and his knowledge and expertise in using technology – had expanded since the practicum, and that his potential would be promoted with the assistance (ZPA) of his colleagues in the Mathematics Department. But this was the case for only *some* colleagues. Many of the other mathematics teachers were unenthusiastic about using technology and favoured teaching approaches that Adam claimed were based on their faulty belief that learning is linear rather than richly connected:

> You do an example from a textbook, start at Question 1(a) and then off you go. And if you didn't get it – it's because you're dumb, it's not because I didn't explain it in a way that reached you.

Because he disagreed with this approach, Adam deliberately ignored the worksheet provided for the lesson by the teacher who coordinated this subject. The worksheet led students through a sequence of exercises where they were to construct tables of values, plot graphs by hand, and answer questions about the effects of each constant in turn. Only then was it suggested that students might use their graphics calculators to check their work. Conflicting pedagogical beliefs were a source of friction in the staffroom, and this was often played out in arguments where the teacher in question accused Adam of not teaching in the "right" way and not preparing students properly for their examinations. Adam realised that as a pre-service teacher he had not noticed the "politics of teaching" because he had the luxury of focusing on a small number of classes and his relationship with a single supervising teacher. He now found himself in a more complex situation that required him to defend his instructional decisions while negotiating a harmonious relationship with several colleagues who did not share his beliefs about learning. Adam explained that he was willing:

> …to stand up and say "This is how I am comfortable teaching". I just walk away now because we've had it over and over and the kids are responding to the way I'm teaching them. So I'm going to keep going that way. But I've made the adjustment that at the end of the topic we'll say "Right, now to get assessed on this you need to do these steps".

In terms of the theoretical framework outlined earlier, Adam has interpreted his technology-rich ZFM as *affording* his preferred teaching approach and he has decided to pay attention only to those aspects of the Mathematics Department's ZPA that are consistent with his own beliefs and goals (his ZPD) and also with the ZPA offered by the university pre-service course. At the same time he has recognised the need to explain more clearly to his students how they should set out their work in order to gain credit for correct solutions to examination problems. One could say that his professional identity has developed to the extent that he is now able to reconcile his pedagogical beliefs (a part of his ZPD) with externally imposed assessment requirements (an element of his ZFM).

CONCLUDING COMMENTS

Valsiner's zone theory, when applied as illustrated in this paper, may help us analyse relationships between teachers' pedagogical beliefs, the teaching repertoire offered by their pre-service course, and their practicum and initial professional experiences, in order to understand how their identities might emerge as users of technology. The analysis presented here has examined how these relationships can change over time within the same institutional setting. In 2005 Adam has been transferred to a different school with very limited technology resources, so it is likely that his interpretation of his new context – the school's ZFM – will be crucial to the continued development of his professional identity, his sense of "being" as a teacher.

Although the three zone framework has been used here as an analytical tool, it could also support teachers' learning in several ways. First, it could help pre-service teachers to analyse their practicum experiences (ZFM), the pedagogical models these

offer (ZPA), and how these experiences reinforce or contradict the knowledge gained in the university program (university ZPA). Second, in the early years of teaching it could be used to create induction and mentoring programs that promote the sense of individual agency Adam displayed within the boundaries of the school environment (ZPD within ZFM). Finally, the framework could assist in the design of professional development for more experienced teachers (ZPA to stretch ZPD).

Acknowledgement

This research was funded by a Discovery Grant from the Australian Research Council.

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