Teacher Professional Development in Patterns and Algebra: Being Sensitive to a Teacher's Zone of Proximal Development

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This paper examines the use of Blanton, Westbrook & Carter's (2005) extension of Valsiner's (1987) zone theory in interpreting one teacher's Zone of Proximal Development (ZPD) with regard to professional development (PD) from teaching experiments. It shows that if what the researcher sets in the PD is outside the teachers ZPD, little teacher development takes place. It also shows that there may be an inherent conflict between teaching experiments and professional development that is hard to overcome.

A new Mathematics Syllabus (Queensland Studies Authority, 2004) is being implemented in Years 1-10 in Queensland that contains new and expanded content, notably in mental computation, chance and data; transformational geometry, and patterns and algebra, and a new emphasis on outcomes based education. The literature shows that this implementation will only be successful if teachers' mathematics and pedagogy knowledge is sufficient to construct connections between concepts in the new content (Kaput & Blanton, 2001; Ma, 1999) and if teachers' beliefs enable them to accept the new content as important for their students (Darling-Hammond & McLaughlin, 1995). This necessitates professional development to introduce content and pedagogy and provide time for critical reflection on beliefs. As yet, no coherent program of such professional development has been forthcoming from the Queensland Government.

However, there has been support for some smaller projects, notably for this paper, the Early Algebra Project (www.acu.edu.au/earlyalgebra). This project's role has been to identify content and pedagogy central to developing project students' algebraic understanding, provide professional development to support project teachers' conduct of experimental lessons, and post information to the website. This paper reports on the success of this project in terms of professional development effects on project teachers.

Zone theory. Blanton, Westbrook and Carter (2005) developed a theory to examine teachers' responses to professional development from Valsiner's (1987) extension of Vygotsky's (1978) theory on Zone of Proximal Development (ZPD). Vygotsky identified ZPD as a range within which a child's potential for learning will occur. He described this as the difference between the level of solved tasks that can be performed with adult guidance and the level of tasks that can be independently solved. He saw this zone as the range in which learning takes place. Valsiner's (1987) used Vygotsky's work to analyse student development and identified a further two zones which he called the Zone of Free Movement (ZFM) and the Zone of Promoted Action (ZPA). The ZFM is set by the adult and it defines what action the child is allowed to undertake and what thinking the child is exposed to. The ZPA is the tangible range of actions that the adult promotes in an effort to influence the child's behaviour. The interaction of these zones is such that the action that is promoted must be allowed and therefore the ZPA is within the ZFM. However, the ZPD can only be stimulated if it lies within the ZPA, while greater potential for development may exist outside the promoted action. This leads to the theoretical model displayed in Figure 1.

Blanton, Berenson & Norwood (2001) extended the use of Valsiner's (1987) theory to interpret the developing understanding of student teachers. This was an extension of zone theory which up to then had been used as an analytical tool only to plan instruction for students (e.g., Hedegaard, 2000; Litowitz, 1993). Blanton et al. (2005) used Blanton et al.'s (2001) earlier theoretical model to analyse experienced teachers' responses to professional development. Blanton et al. (2005) argued that "ZPD is affected by the intellectual quality and developmental appropriateness of interactions with a more knowing other" (p. 5). This is a move away from the knowing other being restricted to a parent or teacher of a child to the knowing other being any person, be it child or adult.
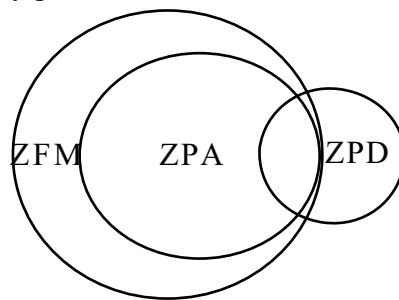

Figure 1. Valsiner's (1987) theoretical model for the interaction of the ZFM, ZPA and ZPD

Blanton et al. (2005) identified an Illusionary Zone (IZ) of promoted action is a zone of permissibility that the teacher appears to establish through behaviours and routines used in instruction but in reality does not allow. IZ was distinct from ZPA in that ZPA should be contained within the ZFM (one can only promote that which is at least allowed) while IZ was that which appeared to be promoted but in fact was not allowed.

This paper uses Blanton et al.'s zone theory to study the early algebra project's professional development with their project teachers. In doing this, the paper evaluates this zone theory as a vehicle from which to support professional development of teachers embracing new content and pedagogy knowledge.

Methodology

The early algebra project is a series of conjecture-driven teaching experiments (Confrey & Lechance, 2001) that longitudinally follows a cohort of students from 5 middle class inner city primary schools from Year 3 to Year 6. The involvement of teachers in the project each year included them coming together for half days of professional development that was focused on different early algebra topics. Following each of these professional development sessions, the researchers and two of the teachers conducted four, one hour experimental lessons that had been written up by the researchers. It is the second lesson from one of these four lessons, conducted by one teacher in Year 3 (the first year of the project), that is the focus of this paper. The lesson focused on early functions and aimed to develop students' abilities to generalise changes involving simple addition (e.g., +3 and +4).

Participants. The participants of the study are the teacher, Helen (pseudonym), and the Year 3 students in her class. Like all primary teachers in Queensland, Helen (pseudonym) is well credentialed having completed a Bachelor of Education degree seven years earlier. However the mathematics component of this degree is small and like most primary teachers in Queensland is not confident teaching the existing mathematics syllabus (Warren & Nisbet, 2000). At the commencement of this project Helen freely admitted that

she had no content or pedagogy knowledge for the teaching of early algebra. However having made these claims Helen then volunteered to be videoed while she conducted the experimental lessons in her classroom.

Data collection. The data collection instruments used in this study were (1) a questionnaire given at the commencement of the study and covering early-algebra content and pedagogy knowledge, and beliefs and attitudes on the teaching of early algebra; (2) records of the PD sessions given prior to the lesson; (3) observations of the one hour experimental lesson given by Helen (recorded by field notes and by video taping and later transcription); and (4) in-depth interviews conducted at the commencement and conclusion of this year of the study.

Data analysis. The lesson video-tapes were transcribed and combined with field notes for a rich description of the lesson. These descriptions were analysed using the method of Peressini and Knuth (1998) to enable discourse to be categorised in a way that allows conjectures about Helen's ZPD, ZFM and ZPA to be made. Once this categorisation process was complete the research team again viewed the videos of the lessons to confirm consensus of the category selection. These findings were then compared with results of the questionnaire and the interviews, and the record of the PD, to confirm findings.

The general consensus of the literature (e.g., Bakhtin, 1994) is that language in the classroom has two main functions: (1) to communicate meaning from one speaker to another; and (2) to provide an avenue to create new meaning. Blanton, Berenson and Norwood (2001) drew on this consensus to develop a framework for analysing discourse to illuminate the translation of professional development to teaching practices. Peressini and Knuth (1998) extended this framework to understanding of how teachers manipulate dialogue and therefore student thinking by asking questions and responding to questions in ways that restrict actions in the ZFM impacting on the ZPA thereby establishing the ZPD.

Results and Discussion

The first lesson that Helen took needed considerable assistant from the researcher. A decision was made not to intervene during Helen's second lesson so that a true representation of the range within her ZPD for the teaching of the new content area would be recorded.

Content difficulties. Helen began her second lesson by setting strict boundaries.

Helen: Everyone put this page on the left hand side of your desk. Your recording sheet in front of you and your number board on top of that.

Helen tried to engage the students in a conversation about the discussions from the previous lesson, however the children cannot recall the aspect of yesterday's lesson that she is referring to. This results in Helen strictly setting the boundaries by blaming the children for not remembering because of their distracted behaviour. On several viewings of the lessons, the general consensus is that the students were in fact well behaved throughout the four lessons and this initial response was an indication of her discomfort with the lesson content.

Helen: There are people fiddling. No wonder so one remembers. Put your pencils down. You can't fill anything in until I show you so don't go racing ahead.

Helen's difficulties with content appeared to prevent her from noticing students' difficulties. The next extract exhibits how Helen, on hearing an answer she perceives as

correct, moves on without recognising the confusion her students are experiencing. The table that is drawn by Helen follows the extract as Figure 2.

Helen:	Repeat what you learnt yesterday.
Nathan:	When you added three the tens changed but the ones didn't.
Helen:	Right. (Completing the table on the board says) Four plus three equals seven, fourteen plus three equals seventeen. Twenty-four plus three equal twenty-seven. So what did we find?
Tom:	Only the ones changed.
Helen:	So if we had thirty-four plus three what would the answer be?
Tom:	Thirty-seven
Helen:	So what changed?
Sue:	The tens
Helen:	No. Nathan told us when you add three, the ones change but the tens don't. So did the tens change?
Children:	Yes, No, Yes, No (uncertainty evident in children's voices)
Helen:	Did the tens change, NO!

INPUT	OUTPUT
4	7
14	17
24	27
34	37

Figure 2. Table drawn by Helen as part of instruction

This extract shows that not only is Helen failing to listen to the actual words spoken by Nathan, she has also failed to recognise and respond to her students' propensity to look down the Table. It is in reading across the table that the generalisation is evident. Identifying the generalisation was the intended focus of the lesson. However children continued to see the pattern of the tens changing down the table. As there was no discussion on how the table was to be read, the children were very confused.

Difficulties with representations. Helen closely followed the provided lesson plan, reading each step before she instructed the children. She introduced a new pattern of +4 involving bridging of tens. Helen tried to demonstrate the addition of four to seven using a flip chart and encountered difficulty with this representation. S had flipped the chart over to nine and then realised that she did not know how to explain regrouping using the flip chart. After some further failed attempts at using this representation Helen then asks the children

Helen:	If I give you eighty-seven, find eighty-seven on your number boards, OK count on four. Jordan what did you get?
Jordan:	Ninety-one
Helen:	Good. What are you finding on your chart?

Mary:	The ones and tens are changing.
Helen:	Tony what is changing?
Tony:	Only the tens.
Helen:	Yes look here. We had twenty-seven and added four and got thirty-one. Only the tens changed. Then we had thirty-seven and we added four and got forty-one. Only the tens changed. And we had forty-one and we added four and got 51. Only the tens changed. Who can't see that pattern?
Children:	No response.

At this stage, Helen herself is confused about the generalisation. Her obvious confusion with the intent of the lesson stimulated specific behaviour that can be placed within Blanton et al.'s (2005) IZ (illusory zone) that is outside the ZPD (zone of proximal development).

The lesson proceeds and the children are instructed to complete the table. Helen stands reading the lesson plan when one boy interrupts her asking for help.

Helen:	Help, you need help. You know why you need help — you were mucking around with Daniel and you weren't paying attention.

Helen did not address this child's concern. As they (and Helen) struggled to deal with this new way of looking at arithmetic, the children appeared to be assuming that they should be able to ask questions. However, when the children did ask questions, they were berated for not paying attention which left them with little room to move and still with their difficulties. It appeared that Helen had managed to confuse herself and her students.

Helen had remained very answer focused and this goes against the fundamental concept of identifying generalisations. She made no real attempt to investigate the pattern. This appeared to be because she did not understand this herself.

Helen:	Britney, what did you find as you worked down your table?
Britney:	That the ones changed.
Helen:	Did we say that the ones changed?
Britney:	The tens changed.
Helen:	OK what happened when we got up to the hundreds?
Britney:	The ones changed.
Helen:	Why are you saying that the ones changed?
Britney:	Because they are a different number.
Helen:	What do you mean a different number?
Britney:	The ones changed to one.
Helen:	I think I know what you are trying to get at. Alex?
Alex:	I think the one and the tens are changing because the tens changed and the ones changed from seven to one.
Helen:	There is a lot of noise going on here. Did you hear what Alex said Paul?

Helen stalls for time as she tries to recover her position of the all knowing teacher. Her efforts seem to be designed to confuse the children by glossing over the content and making general unrelated statements. An example of this can be seen in the following extract where Alex repeats his explanation of the change in the pattern and Helen responds.

Helen: OK what do we call it? (time lapse) When we are doing it (time lapse) It is sort of like when we are regrouping. Isn't it? OK let's go on.

Creating illusions. Helen is creating this illusion that she appears to be open to questioning but in fact is not. She is unable to explain and so pushes on with the lesson plan leaving the children unable to understand the concept being taught and to believe that there is something wrong with them as they fail to interpret the concept. It appears a reasonable conjecture that the whole lesson was conducted in the IZ — that the focus of Helen's teaching was survival.

There were several tactics that Helen used in order to endure and survive the lesson. First, there was very limited opportunity for students to ask questions. Helen kept the lesson moving. Second, on the several occasions when students did ask questions, they were criticised for not paying attention and their concern was not addressed. The teacher appeared not able to truly listen to her students because she was too uncomfortable with her own lack of knowledge. Her way around this was to embarrass the children who asked questions. Third, when it was no longer possible to avoid a discussion of questions, Helen's responses failed to satisfy the student's inquiry — the replies did not address the students' concern. In particular, when Britney and Alex pushed Helen with questions on what changes were occurring in the lesson, she skimmed over it saying it is like regrouping.

It seems that, in this instance, when new content was introduced, Helen's ZFM, ZPA and IZ became distorted from that described by Blanton et al. (2005). The IZ seemed to dominate this teaching episode with the data. Hence, it could be argued that the model of interaction for Helen's teaching is a modification of that described by Valsiner (1987) (see Figure 1) as in Figure 3.
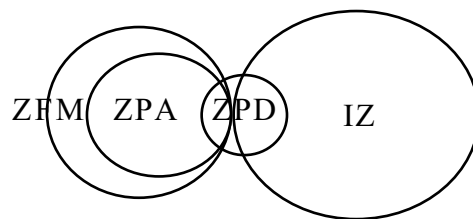

Figure 1. Modification of Valsiner's (1987) for Helen's lesson

It could almost be argued that there is a further zone present within the IZ. This zone could be called the Zone of Survival and as for Helen's lesson this zone could be seen to dominate the IZ. It could be conjectured that this zone may be stimulated when a teacher feels threatened, for example, by lack of content knowledge, or possibly even behaviour problems, This feeling of threat can be seen to promote very specific actions on the part of the teacher. Thus a zone of survival could be seen as when the teacher believes they are teaching but in reality they are only interested in "getting out alive". Survival always seems to be present as teachers never know what to expect from children. It becomes inflated as the pressure increases and so learning fails to occur.

Relation to other data. In her interview, Helen believed that she was an adequate or

"OK" teacher, but that she was concerned about her content knowledge. In this, she recognised her weakness — she did have content problems.

It was evident that there were aspects of the professional development (PD) program that had not been presented in a form that Helen could receive. Helen was operating on the notion that closure was important in mathematics teaching and was therefore answer focused. She did not seem to understand the simplicity of the concept that addition could be understood as change and did not seem aware that the crucial component of the lesson was to facilitate the students into generalising this change. In other words, she did not use the classroom dialogue to inform and to construct the desired meaning (as argued by Bakhatin, 1994).

In terms of the theory by Blanton et al. (2005), the PD provided was not sensitive to her zone of proximal development (ZPD) and so there was little learning on her part with respect to the early algebra ideas. This reinforces the work of Blanton et al. by showing that sensitivity to teachers' ZPD is an important issue in the provision of PD. A more interactive approach is needed in PD to allow teacher ZPD to become apparent within interactions and, therefore, able to be taken into account.

Final note: There were four lessons involved in the Year 3 trial of arithmetic as change, so two lessons were planned to follow the one described in this section of the paper. Thus, Helen had two more lessons to teach. However, such was her difficulty with early algebra that the researcher observing her lesson co-taught the lesson. In the last lesson, at her request, the researchers taught the whole lesson.

Conclusions

The lesson is rich in findings with regard to the teacher (Helen), the interactions between Helen and her students, and the relation of this to Helen's knowledge learnt from the PD session prior to the lesson trials.

Summary. First, Helen displayed strong survival strategies or tactics, notably redirect (when Helen was asked a question for which she did not know the answer, she accused the student of not paying attention) and dissemble (when openly challenged to give an explanation, as with Britney and Alex, she made a feeble attempt to explain and then moved on. Helen failed to listen to the children and heard what she wanted to hear. For example, as with Nathan at the beginning of the lesson, she failed to be attuned to students' failure to grasp the objective of the lesson.

Second, Blanton et al.'s (2005) theory provides interesting explanations of teacher behaviour observed in the lesson. It was evident that Helen operated in the Illusory Zone (probably in a zone of survival, if one was to be conjectured). From the experience of Helen, it is evident that teachers operating in the IZ will say that the PD and the lessons are not successful and continue with old habits when support for their actions weakens. As Day (1999) stated:

> Development takes what is there as a valuable starting point, not as something to be replaced, but a useful platform on which to build. To do so is to recognise not only that teachers do have valuable existing expertise but also that, if teachers are forced to choose, they will usually revert to their secure established ways of doing things (p.271).

Third, the PD did not provide an avenue for meaningful discourse to develop between the researchers and Helen.

Implications. First, there is a relationship of mutual responsibility between researchers

(who are the PD leaders) and the teachers. It is insufficient for the researchers as experts to simply give recipes at the PD seminars for the teachers to directly use in their classrooms. It is insufficient for the teachers to simply copy what the researcher has done. As Day (1999) argued:

> Teachers cannot be developed (passively). They develop (actively). It is vital, therefore that they are centrally involved in decisions concerning the direction and process of their own teaching (p.2).

Second, there is a conflict between the needs of the researchers undertaking teaching experiments and the needs of the teachers undertaking PD on the results of the experiments. The researchers are pushing the envelope, seeing how much is possible in terms of student comprehension and learning. This means that the PD is stretching the teachers beyond what they are ready for or capable of; that is, in Blanton et al.'s (2005) theory, the ZFM and the ZPA (what the researcher/PD leader does) is outside the teachers' ZPD. This leads to problems of cognitive load in both the PD and the experimental classes; the teacher has no spare capacity to focus on students' reactions other than to use tactics to reduce their impact. The teachers' content is inadequate in terms of Kaput and Blanton (2001) and Ma (1999) and their beliefs are insufficient in terms of Darling-Hammond and McLaughlin (1995).

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