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**Extending teacher education students' mental models
of teaching and learning through Problem Based
Learning**

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Abstract

This paper reports student teachers' reflections on changes in their mental models of teaching and learning following their experiences of a problem based learning (PBL) topic. Students develop robust mental models of teaching and learning during their school years. Mental models inform intentions and plans, which in turn inform actions. As such, teachers often teach as they were taught—possibly perpetuating practices that limit intellectual inquiry in classrooms. PBL was introduced to our Bachelor of Education (B.Ed.) to challenge and extend students' mental models about teaching and learning, with a view to influencing their prospective teaching actions.

We created an analytical framework and identified key-word descriptors of change to guide categorisation of 105 students' focussed written reflections on their PBL experiences.

Results provide evidence that students do report changed mental models in areas such as, 1) the value of case studies for engaging with subject content, motivating learning and connecting theory with practice, 2) self-reflection and peer collaboration for cognitive and professional growth, and 3) PBL processes of inquiry for developing self-regulated learning practices.

Key words: Problem based learning; changing mental models; self-reflection; teaching and learning; teacher education

“I am so grateful that I have experienced PBL. PBL has opened up to me new and different ways of thinking which I would never have experienced otherwise. PBL has also brought meaning and solid connections between my university study and real-life teaching. The skills that I have learnt in PBL have catapulted me on a new journey of life long learning. I also believe that the use of real-life cases have enabled us to think like teachers and to experience real problems that as teachers we will encounter on a day-to-day basis. Finally, I believe that PBL has been effective in increasing my research skills, collaborative group work skills and self-directed skills.”
(Bachelor of Education student, 2005)

Introduction

Mental models about teaching and learning

Cognitive schema theory (Anderson, 2005) proposes that people draw from their prior experiences to develop mental models that provide the frameworks for understanding events. Mental models are representations of situations, both real and imaginary (Johnson-Laird, 1999; Johnson-Laird & Byrne, 2003). It is not difficult to conceive that prospective teachers’ experiences during their own schooling years would contribute to the formulation of substantial mental models about the nature of teaching and learning. For example, Feiman-Nemser (2001) told how pre-service teachers come to teacher education with a wealth of knowledge, good and bad, about teaching and learning gained through years of first-hand experience with schooling. Work by Entwistle, Skinner, Entwistle and Orr (2000), Northfield and Gunstone (1997), and Whitebeck (2000) suggests that pre-service teachers hold emotionally charged beliefs, consciously constructed conceptions and innate self-ability attributions about teaching that are drawn from their relevant life experiences (including teaching practicum, but also their own experiences as pupils, experiences with their own children and representations in the media).

However, ideas about good teaching and learning practices change from generation to generation. For example, current prescriptions for scaffolded guided discovery, social-constructivist class discussions, collaborative group work, peer feedback, reciprocal teaching, communities of learners, self-regulated learning, and reflective practice (Bransford, Brown, & Cocking, 2000) were in theoretical development, and not explicitly transferred to classroom practice, when many current pre-service teachers were at school. This is particularly salient for a large number (in Australia) of mature-age students enrolling in teacher education courses.

Thus current pre-service teachers’ mental models about teaching and learning in school are likely to be substantially informed by practices such as the teacher as ‘fount of all knowledge’, chalk and talk, worksheets, seat-work, between-student competition and IRE questioning (initiate, respond, evaluate) (Bruning, Schraw, Norby, & Ronning, 2004). For example, Klein (1996) investigated pre-service teachers’ epistemologies and conceptions of learning and proposed a range of factors that represented ‘the many controversies that characterise educational thought’ (p. 368). Of interest is Klein’s finding that traditional transmissionist views and

contemporary constructivist views could be held simultaneously by participants. At worst, these divergent beliefs could be interpreted to imply that participants held a non-coherent body of knowledge. At best, both beliefs could be held, and selectively applied according to specific teaching contexts.

Translating mental models about teaching and learning into teaching actions

A major premise underlying our research is that students need to develop good quality mental models about teaching and learning, because those mental models will inform their plans and actions in their prospective classrooms. This point was argued by Kerr (1981), who proposed that good quality teaching actions are informed by good quality intentions and plans, which are in turn informed by good quality knowledge about teaching and learning. An example of the profound influence of teachers' mental models of teaching and learning is provided by Stigler and Hiebert's (1999) analysis of their collected videotapes and questionnaire responses from teachers in Year 8 mathematics lessons across the United States of America, Japan and Germany. In the authors' extensive review of their data, one striking observation was of teachers' approaches to implementing new curricula and ideas:

Teachers can misinterpret reform and change surface features--for example, they include more group work; use more manipulatives, calculators and real-world problem scenarios; or include writing in the lesson--but fail to alter their basic approach to teaching mathematics. (Stigler & Hiebert, 1999 p. 106)

One explanation for such findings is provided by Argyris and Schön's (1974) proposed 'espoused theories' and 'theories in use'. If teachers ascribe to 'new' teaching objectives but basically hold on to 'old' or 'comfortable' ideas that worked for previous objectives, students may only respond to the latter.

An example of a failure to transfer metacognitive strategies from personal learning to teaching contexts was illustrated in a study by Thomas and Barksdale-Ladd (2000). In that study, student teachers received intensive training in strategies for reading, including reading for meaning and checking comprehension. Consequently, the student teachers improved their own strategic approaches as well as their ability to write about, and talk about, those approaches. However, participants reverted to more traditional graphophonic decoding teaching strategies when their roles changed from student to teacher. Thomas and Barksdale-Ladd concluded that participants, "appeared to operate under two definitions of the reading process witnessed through what they did and what they attempted to teach their tutees" (Thomas & Barksdale-Ladd, 2000 p. 67). One explanation for this finding is that students relied upon their earlier mental models of teaching to inform their teaching behaviours.

Recently, Day (1999a; 1999b) revisited Argyris and Schön's espoused versus theories-in-use dichotomy to point out the dilemmas that teachers contemplating change might face, such as appearing incompetent while new strategies are practised, the emotional burden of self-confrontation, and the tendency to draw upon existing frameworks to solve problems because opportunities to develop new frameworks through formal or informal training and reflection are not made available. Teachers need exposure to current best practice, contextual support, and personal commitment

to enable them to change their teaching and learning theories and to match their new theories to their teaching practices (Jakubowski & Tobin, 1997). The experiences of Gitlin and Hadden (1997) suggest that a support network of like-minded colleagues appears essential for such an interaction to evolve.

Problem-based learning

PBL is seen as being a pedagogical method that has the potential to facilitate the construction of good quality mental models about the selected subject-matter and to stimulate change in those models. In the case of teacher education, the method of instruction serves a dual purpose, not only facilitating the acquisition of subject matter knowledge, but also providing a model of teaching and learning practice that is well-founded in contemporary teaching and learning theory.

A general model of PBL involves the progressive presentation of well-structured case studies to small groups of students. The students' tasks are to identify the current state of their knowledge, identify what further information is needed, seek out that information, analyse and evaluate the information, and make plans for action viz-a-viz the case.

A range of benefits of PBL have been claimed. For example, Spencer and Jordan (1999) argued that PBL classes were associated with deep, rather than surface, thinking; self-direction in learning; more stimulating learning environments; increased interaction between students and teaching staff; improved motivation and better knowledge retention. Capon and Kuhn (2004) proposed that students exposed to PBL instruction more often showed increased facility to integrate newly acquired constructs with existing knowledge structures. This finding is supported by Gijbels and colleagues' (2005) meta-analysis of learning outcomes in PBL versus traditional settings. In that study, the authors differentiated the level of student knowledge (declarative, procedural, conditional) that was assessed, and found that PBL appeared particularly effective in assisting students to develop understandings about underlying principles that link concepts.

In the field of teacher education, Murray-Harvey and colleagues (Murray-Harvey, Curtis, Cattley, & Slee, 2005) identified substantial gains over time in PBL teacher education students' self-rated competence on four generic skills of problem-solving, namely, communication skills, discipline knowledge building, and personal and interpersonal development.

The opportunity that PBL provides for developing more extensive knowledge networks through authentic situations, targeted research, and multiple opportunities for encoding information, is related to psychological constructivist principles of learning (Anderson, 2005). Meanwhile, the key role of the learning group in PBL reflects social constructivist explanations for how individuals construct and transform knowledge and conceptual understanding through dialectical activity (Hmelo & Evensen, 2000; Hmelo-Silver, 2004; Vygotsky, 1978).

The learner-centred (Alexander & Murphy, 1994) approach of PBL is operationalised in a number of ways, including that, students work in small, tutor facilitated groups; students are supported to be actively involved self-directed learners; and the learning

process requires inquiry into authentic problems (Colliver, 2000). The ill-defined, 'real-world problems' that students are presented with in a PBL case provide "opportunities to make visible that the very struggles they face (as teachers) are not unlike those of scientists trying to create new knowledge" (Kelly & Green, 1998, p.177).

Problem based learning and teacher education

There is a need for teacher education programs to substantially challenge students' prior understandings about teaching and learning, and to provide imperatives for students to engage with, and use, current prescriptions for best practice. This endeavour is likely to require teacher educators themselves to reflect upon their own practices, as evidenced by Feiman-Nemser's (2001) concern that

the typical pre-service program is a weak intervention compared with the influence of teachers' own schooling and their on-the-job experience (Feiman-Nemser, 2001 p.1014).

We have considered the aims of the B.Ed. offered by our university, and the ways in which these aims can be realized through instruction. As a result of studying in the B.Ed., our students are expected to develop a clear sense of what it means to be a teacher, that is, to develop their professional identity, including development of the following qualities

- A passion for learning and enquiry (Self-Directed Learning)
- The capacity to negotiate effective relationships with students, teachers, parents and community members, cognizant of cultural, social, economic and political differences (Professional Collaboration)
- Confidence in their approach to classroom practice, with an ability to read and shape the contexts in which they teach, and draw on their depth of knowledge in the fields of study that are related to the key learning areas (Knowledge Building)
- The capacity for critical reflection on teaching practices and theories, on their own teaching and their lives, using these reflections to inform their practice (Critical Thinking)
- Attitudes that engender active support of policies and practices that take account of social and individual differences and ensure that all students learn (Theory-Practice Relationships)
- Attention to social justice in our democratic society, acting powerfully in their classrooms, schools and communities (Theory-Practice Relationships)
- A striving for excellence and creativity in their teaching (Self-Directed Learning)

- Confidence in the use of information and communication technologies and the new literacies (Knowledge Building)

We determined that the aims of the B.Ed. were in parallel with the proposed benefits of the PBL instructional approach. Therefore, we developed, trialled with a small group, and are now progressively offering to larger cohorts of pre-service teachers, a PBL approach in a core topic in our teacher education program. The flowchart in Figure 1 represents our alignment of the aims of the B.Ed with the aims of a PBL method of instruction, and their translation into a course design. It can be seen from Figure 1 that themes of knowledge, critical thinking, self-directed learning, theory-practice relationships and professional collaboration emerge as joint aims of the B.Ed. and of the PBL method (Chernobilsky, Dacosta, & Hmelo-Silver, 2004; Colliver, 2000; Hmelo & Evensen, 2000).

The present study

According to McPhee (2002) "there would, on the face of it, appear to be a good case for the introduction of this [PBL] methodology within initial teacher education" (p. 65). However, while PBL has been adopted and evaluated in a number of ways in medical education, there has been relatively little research published on PBL in teacher education settings.

We have brought together our interest in developing the quality of pre-service teachers' mental models about teaching and learning with our interest in further investigating the potential benefits of PBL as a pedagogical approach. Our specific aim in the current study lies with identifying whether pre-service teachers' mental models about best practice in teaching and learning change as a result of their exposure to the PBL experience. We take from our review of the literature that such change in mental models is a pre-requisite for change in teaching practice.

One way to investigate the nature of students' mental models is to ask them to openly reflect upon the issues at hand in order to make their thinking available for researcher interrogation (Ericsson & Simon, 1993). Extensive work by researchers into students' perspectives about issues such as classroom climate and teacher qualities attests to the value of attending to the voices of students who have first hand knowledge of the instructional experiences that we design and deliver (Cooper & McIntyre, 1995, 1996; Fraser, 1996; Fraser, 1991, 1995; Morgan & Morris, 1999; Rudduck, Day, & Wallace, 1997; Rudduck & Flutter, 2000).

An essential part of our PBL program is for students to engage in focussed reflection upon their learning experiences. We therefore identified the students' end of semester assessment task, which was a written reflection to focussed questions, as a source of data that we could interrogate to identify indicators of change in students' mental models of teaching and learning.

The question that guided our research was, "Do teacher education students report changes in their mental models about teaching and learning as a result of their engagement with PBL?"

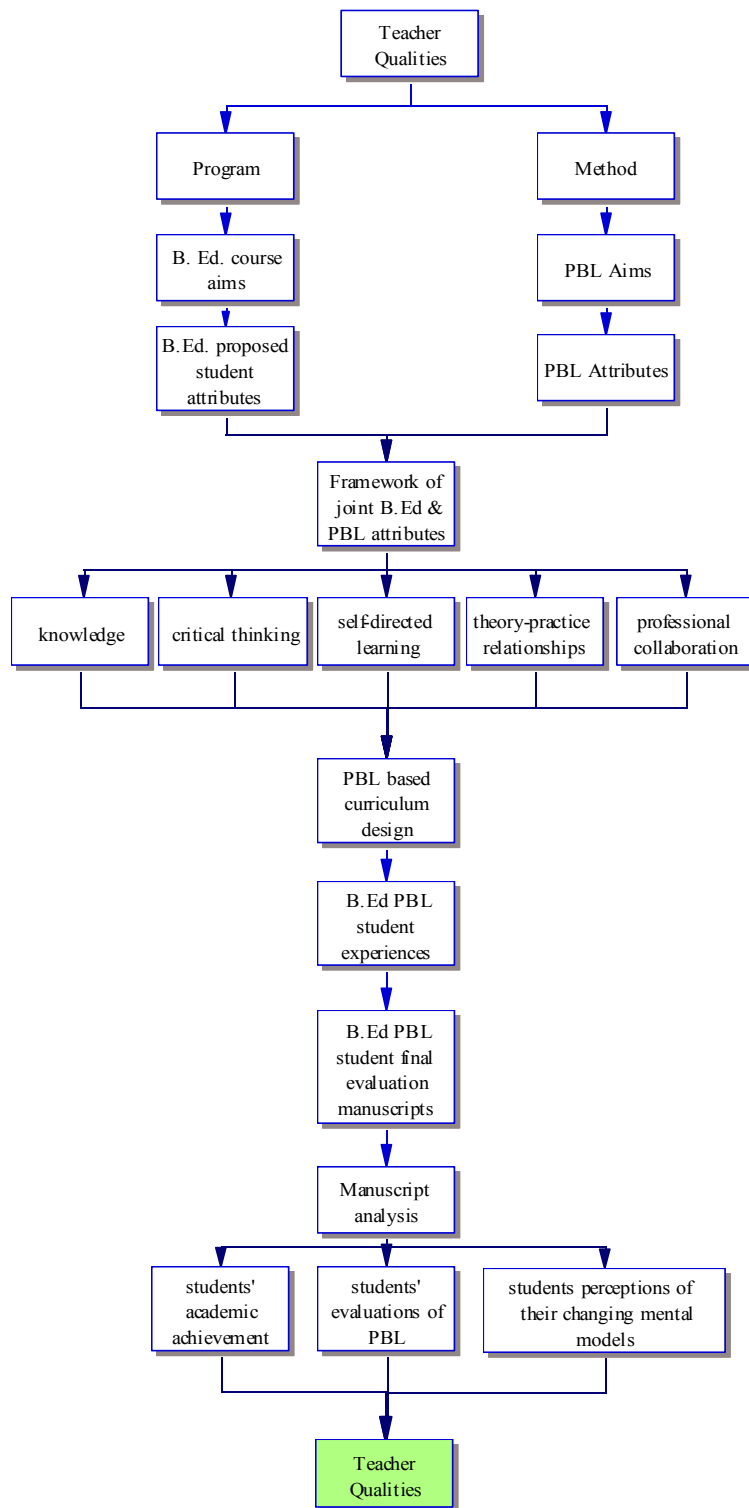


Figure 1: Alignment of the B.Ed. aims and the PBL method of instruction

Method

Ethics

Ethics approval for the study was granted by the Flinders University social and Behavioural Research Ethics Committee. All participation was voluntary, and participation or non-participation was without prejudice to students' enrolment or progress in the course. All data was stored and is reported in a non-personally identifiable form.

Context

The participants

One hundred and fifty-three PBL strand teacher education students (of the total enrolment of 207) volunteered to join this study. Of those, 105 had submitted manuscripts by the cut off date for data collection. The students were enrolled in the third year of a four year undergraduate B.Ed. program or an equivalent first year of a graduate entry B.Ed. Program. Students were predominantly female, including students progressing without a break from secondary school to university, as well as mature age students re-entering formal education.

The topic of instruction

The PBL cases were embedded within the B.Ed. topic 'Development Learning and Teaching' (DLT). One aim of the DLT topic is that students will gain knowledge about issues related to childhood development, and the interactions between development, learning and teaching. This topic also includes a range of objectives that explicitly address preparatory work related to current knowledge about good teaching, such as teachers' work; strategies for building relationships with students, parents and colleagues; and, establishing a positive climate for learning. The topic provides students with information on the principles underlying the PBL tutorial process, such as working as a collaborative member of a team; engaging in self-directed learning; and, developing research and presentation skills. Table 1 provides an overview of topic program, including class contact hours, practicum hours, case-study program, and assessment tasks.

Table 1: The Course Program

Tasks/Activities	Week 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Reflective journal entries	—————															
Case Study 1		—————														
Lectures	—————															
Mid-term student evaluations of PBL						—————										
Case Study 2						—————										
Teaching practicum								—————								
Tutorial self-assessments						—————										
Collaborative group work preparation time				—————									—————			
Group presentations of case study solutions					—————									—————		
End-of-semester student evaluations of topic															—————	
Learning evaluation final assessment task															—————	

Line markers signify location and duration of each event in the course program

The PBL case studies

The PBL program followed a 7-step procedure in which the ‘story’ of a well-designed, written case study is revealed to students progressively over a series of tutorials (Schmidt, 1983). The cases were developed to ensure that, 1) the students would cover the content of the topic; 2) that the cases represented teacher problems not student deficits; and 3) authenticity – representing actual events and prepared in consultation with practising classroom teachers. The PBL case-study groups were supported by experienced tutor/facilitators. Box 1 contains an overview of one of the case studies.

Box 1: Sample Case study abstract - Harvey High

<p>ABSTRACT</p> <p>This case extends over three weeks focussing on developmental issues related to adolescence and educational issues relevant to upper secondary level schooling in a Yr 8-12 setting. The students will consider how to cater for the learning needs of Pat, a Year 10 student who has failed Year 10 Maths but wants to continue with high level Maths into his Senior Years despite his Maths teacher’s advice not to.</p> <p>Pat persists in his efforts to gain approval to continue with his level of Maths by pleading his case with other School Staff. Subsequently the Deputy Principal interviews Pat and his parents and decides to give Pat a chance to prove himself.</p> <p>Pat’s teachers must explore ways to meet his specific learning needs by understanding the large range of factors influencing in this situation.</p> <ul style="list-style-type: none">• In Tutorial 1 students are introduced to Pat and the school context. Students initially do not know if Pat is a male or female student. This becomes apparent at the end of Tutorial 1 when students are given a copy of Pat’s report.• In tutorial 2, the students gain further insight into Pat’s situation through a parent-student-teacher conference.• In Tutorial 3, after sharing their research findings, each small group of students make a short presentation of the important factors that Pat’s teachers need to consider in supporting his learning needs <p>Following the presentation students prepare an individual report to the Deputy Principal of the senior school (500 words) that outlines the factors they need to consider in order of importance, with justification for these, with reference to the literature.</p>
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The conceptual framework

We determined that the framework of joint B.Ed and PBL attributes, as displayed in Figure 1, could be further developed as a tool to guide the tasks that we set for students’ learning, and also, to guide our analysis of the data collected for this study. As such, we further differentiated the five categories (knowledge; critical thinking; theory-practice relationships; collaboration; and, self-directed learning) into

subcategories that represented different situations where each of the five major categories might exist in practice. The differentiation of the five major categories into subcategories is displayed in Figure 2, from which it can be seen, for example, in the first column, that one manifestation of relationships between theory and practice is where a student makes explicit links between their PBL experiences and their stated teaching intentions.

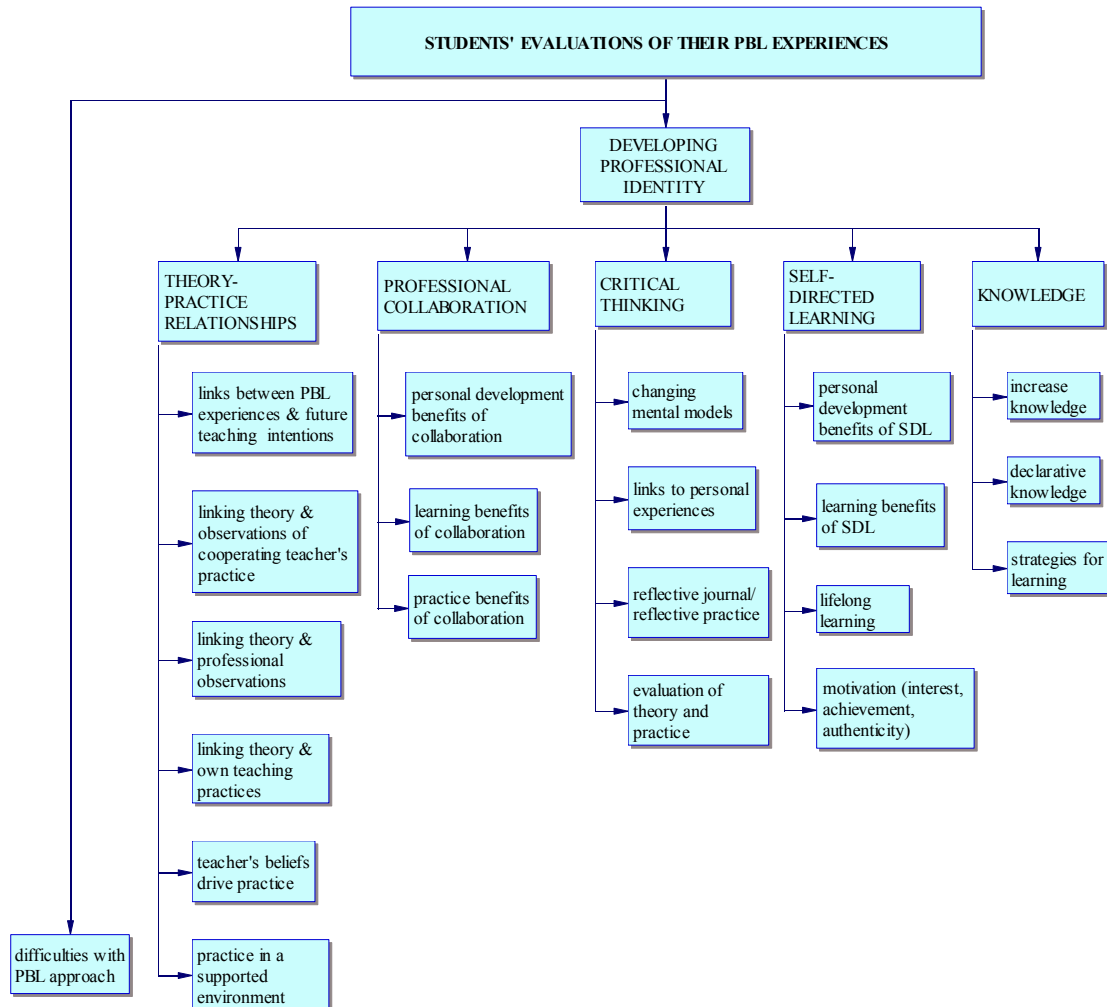


Figure 2: Conceptual framework for coding students' written reflections.

The written reflection task

For their final assessment task, due at the completion of the semester of PBL instruction, students wrote a 2000 word paper in which they considered their PBL experiences and evaluated how effectively the PBL approach to teaching and learning contributed to their professional development. We are guided by our theoretical position that if the concepts central to PBL are functionally active in students' mental models, then those concepts will be used by students when they compose their reflective responses. We constructed assessment questions designed to focus students' written reflections upon the five areas of the conceptual framework (Figure 2). The assessment questions are included at Box 2. It is from this written reflection assessment task that we obtained the manuscripts that form the data base for this study.

Box 2: Assessment questions for written reflection task

Consider your PBL experience in DLT and evaluate how effectively the PBL approach to learning has contributed to your development as a teacher in the following areas:

1. Knowledge Building. You will need to demonstrate an understanding of the content covered in DLT with reference to, and accurate use of, terms and concepts encountered in the topic.
2. Critical Thinking. You will need to compare, contrast and evaluate theories of child development.
3. Theory-Practice Relationships. You will need to show how an understanding of developmental principles can be transferred to classroom practice using specific examples.
4. Professional Collaboration. You will need to reflect on professional understandings about working collegially gained from journal reflections and school experience (or equivalent experience).
5. Self-Directed Learning (SDL). You will need to reflect on your experiences as a learner and knowledge gained over the semester about whether the instructional approaches have supported SDL (i.e. actively engaging in managing your learning alone and with others).
6. Any Other. You may wish to discuss other aspects of the topic that have contributed to your understanding about development, learning and teaching. For example, your feelings, motivations, beliefs about being a teacher.

Manuscript analysis

The manuscript analysis was undertaken in three steps: 1) a content analysis for key descriptors of change; 2) a thematic analysis of students' written reflections in the five categories and subcategories of the conceptual framework, and 3) an intersection of the content analysis and the thematic analysis in order to identify changing mental models specifically linked to PBL experiences.

Step 1: Content analysis

From a search of the problem-based learning literature (e.g. Hmelo-Silver, 2004) we identified key-word descriptors of changing mental models in PBL environments. The descriptors were entered into *N6* (NUD*IST) (QSR, 1991-2002) computer software to guide a content analysis of the 105 students' written reflections. In addition, as our reading of participants' reflections progressed, we identified key words from the students' manuscripts that also indicated changing mental models. These manuscript generated key words were included in the *N6* content analysis.

Step 2: Thematic analysis

For in-depth thematic analysis, we randomly selected 17 students' manuscripts for further investigation. From that random selection, students' grades (as independently marked by tutors) were as follows: High Distinction:1; Distinction:2; Credit:10; Pass:2; Incomplete:2. Thus a range of students' academic achievement was represented. Eleven students were female and six were male, which is an over-representation of males (a result of the random selection procedure) given the predominantly female teacher education cohort.

We repeatedly read the 17 manuscripts and coded them for the presence of one or more of the five categories of the conceptual framework (see Figure 2). We discussed our coding decisions until agreement was reached.

Step 3: Intersecting the content analysis and the thematic analysis

Using the 'intersect' function in N6, we identified statements that were coded in *both* of steps 1 and 2 above, in order to provide thematically categorised evidence of students' changing mental models in PBL environments.

Although it was beyond our resources to conduct an in-depth thematic analysis of all 105 manuscripts, our reading of the manuscripts for other purposes (i.e. assessment) suggests that the contents of the randomly selected 17 manuscripts were representative of the responses of the whole participant group.

Results

Content analysis

The content analysis identified that all 105 students' manuscripts contained one or more of the words that we identified from the literature as descriptors of change. Table 2 contains a list of the descriptive words (column 1), the number of manuscripts containing each descriptor (column 2) and a sample statement illustrating the use of each descriptive word (column 3). From Table 2 it can be seen that students generated words such as *change* ($f=67$), *new* ($f=72$), *gain* ($f=80$), *reflect* ($f=93$), and *different* ($f=103$), at higher frequencies, through to *acquire* ($f=21$), *more aware* ($f=13$), and *open mind* ($f=6$), at lower frequencies. Although this type of frequency analysis is relatively coarse and undifferentiated, it does provide an indication that students generated words identifying change when writing about teaching and learning.

Table 2: Descriptors of change, their frequencies and examples from students' written reflections.

Term	Count	Example from manuscripts
different	103	The DLT was very different to any topic I have ever done at university. It offered me challenges and discussed issues I had not considered before.
reflect	93	Ultimately I have done some good growing and learning through DLT and the PBL approach. I have synthesised more knowledge, and come across more information, then on average. The link between theory and practice comes clearer with both PBL and the reflective journal. The PBL approach, and journal, also worked toward building on reflective processes, particularly in the context of theory and one's teaching. Important lessons that only come about through practice and reflection also come clear. Finally, my group work skills – and coping mechanisms – have developed.
gain	80	I believe that the PBL approach has helped me to gain a better insight into what is expected as a teacher. I now have an understanding of the importance of developing relationships with colleagues, parents and students; as well as the importance of friendships between the students.
new	72	Being a part of the PBL approach has been a new and positive experience for me. It helped me learn such skills as time management, interdependence, negotiation and selective skills.
change	67	The second case about Alex then allowed me to improve as I changed my way of thinking by not focussing on 'the answer' but rather on a variety of issues most of which focussed on changing the learning environment around Alex.
discover	58	I found that working in the group and managing our own workloads and schedules was more effective than an instructional approach. I am surprised at this in a way because I would have guessed that I would have preferred a more instructional approach as I have sometimes found it to be difficult to work in a group as group dynamics can occasionally be threatening and therefore stifling. It was interesting to discover just how social I am when it comes to learning and this in turn supported a lot of the discussions we'd been having and work we'd been doing about constructivist approaches to teaching. I had proved to myself, by using myself as the example, that learning is more effective when students feel comfortable in their surroundings, are enthusiastic about what they do and when they have people around them to offer help, support and inspiration.
realise	53	What I did like about DLT and the PBL approach, especially throughout the case studies was that there was no right or wrong answer. It has been discussed that an effective classroom is one where it is a safe place to conjecture and make mistakes. It has been shown that students often learn a great deal by listening to others and analysing mistakes, and that you should give students this opportunity to change their minds about conjectures and possible solutions. Constructivism builds a classroom environment that encourages risk taking. I feel that this was proven to be effective in our topic as we as student's responded by being unafraid to have a go, which would often mean making mistakes, and judgements about the case studies that were never labelled wrong. This contributed to my development as a teacher as I realised that it is most important for we as teachers to develop a relationship with our students in which they feel confident about taking risks and making mistakes in the classroom.
previous	53	I have reinforced a lot of information I had previously taken for granted in working towards the case studies in PBL. I have also learnt a lot about developmental theory, the negative and impacts of certain actions and choices you make as a teacher, and also the Greek culture. In regards to the Greek culture, the aspect of collectivism, as described in an article revolving around the Alex case in our PBL tutorials, was especially interesting and useful to me (Quiroz, Greenfield & Altchech, p. 69). I had never reflected on that sort of approach to community and learning before, and had always thought of our society's emphasis on individuality and individualisation to solely be a 'good thing'.
increased	46	The PBL approach very much supported self-directed learning, as I had to think, discover, develop ideas, and reflect on what I had done. It has increased my capacity for reflection, and I feel able to embark upon new problems without being scared or tentative.
adapt	37	The PBL approach was new to me in the sense that I have not participated in such a self-directed topic before. Initially, this was difficult to adjust to, as I found myself wanting clarification from the tutor on many points. However, I surprised myself with the way in which I adapted, and soon took responsibility for my own learning
insight	32	It has been great to role play with other student teachers through the PBL case studies and look at the cases through the perspective of teachers, instead of students for a change. It was interesting to get this insight into my future working environment, student-teacher relationships, development of children and learning how to teach more effectively.
acquire	21	By questioning and hypothesizing about the theories we were given through the PBL cases, we (the students) would acquire far more knowledge as opposed to knowledge building by research on a set one item criteria.
more aware	13	I have experienced a new way of learning that I first started of not knowing what to do, to becoming more independent and able to work through situations on my own. Over the semester I have learnt a lot more to do with teaching than I have over the past 2 years of university. I found that this topic allowed me to explore teaching issues and issues to do with young students. It has made me more aware of what teaching is going to be like and as stated in my week 14 journal entry, "I have a better understanding of where I am headed and the way I feel towards that," as well as "I have developed the skill of trying to get along with everyone, and I feel more confident in talking to others." "I feel more confident in being a teacher."
open mind	6	Obviously, not all of us approached the case study from the same standpoint, and the group had to compromise on some of our recommendations and ideas about how to organize the presentation. This very closely resembles the school community in which teachers hold varying opinions about which developmental models are paramount, and requires effective listening and an open mind.

Descriptions of changing mental models within categories of the analytical framework

In the discussion that follows we present a selection of extracts from the manuscripts that illustrate students' perceptions of their changing mental models in the categories and sub-categories of the conceptual framework.

Theory-Practice Relationships

Links between PBL experiences and future teaching intentions

It is encouraging to see students making direct links from their PBL experiences to their future teaching intentions, such as Student 4's plan to facilitate the allocation of group roles to provide all students with leadership opportunities, and Student 5 and 7's explicit intentions to use PBL in their own classrooms:

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- Student 4 The collaborative learning we experienced during the PBL process was instrumental in teaching me a few things about my role as a member in a group. I found that I was taking on far too much of a dominant contributing role in the group, which did not allow the quieter members of the group to contribute as much as they could ... This really brought home to me the need for all students to experience the various different roles as dominant students need to have a turn at following the leadership of others and the more passive students need the opportunity to lead (Barry & King, 1998). Teachers must facilitate this allocation of group roles to ensure that it is fair and equitable.
- Student 5 Overall I found PBL hard to get used to. It is an effective way of learning however, and through the process of writing this paper I have realised how much more I have gained from this approach than I probably would have with a more traditional approach. I have gained a great deal of knowledge concerning the effects family, peer to peer and teacher to student relations can have on learning, and the pros and cons of the different options in dealing with situations. I have a far greater understanding of the many theories of child development and have been able to identify the theories used in practice in the classroom. I now believe problem-based learning is a style of teaching that I would use, where appropriate, in my own classroom.
- Student 7 PBL really helps to build up SDL skills, as the teacher does not sit in front of the class lecturing the students, rather the roles of the teacher in PBL as Levin (2001) puts it are lecturer, facilitator, foil, coach and assessor. So the teacher isn't there to give you direct instructions, rather the teacher gives you the information you need, and will then only help to guide you through the process, meaning that the students are directly responsible for the direction they want to take. I really enjoyed this aspect of PBL, because I meant that I had to become involved in the project, I couldn't just sit back and have everything handed to me, I had a say in what I wanted to do and how I wanted to do it, which was a welcome and complimentary change to the rest of the work I have been doing at university so far ... I think that this is the sort of thing I should try to adapt into the classroom when I become a teacher because it may be easier to teach new things to students if you are allowed them certain freedoms with their research, and making students active learners... The PBL approach has given ... me a number of strategies that I may need to implement into my own classroom one da
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Links between PBL and the teaching practicum

Student 2 linked her observations of teacher collaboration during her practicum with her experiences of PBL, and thus the two approaches to her pre-service training complemented each other. This student's observation supports our consideration that an important component of the design of the B.Ed. is the temporal juxtaposition of the PBL and teaching practicum experiences.

Student 2 At the start of the semester I was quite unsure of the significance of a PBL study and felt that it lacked relevance in relation to our future roles as teachers. The main reason was because most of the work was group centred, and I felt that when we are going to be teachers in a short while, it will be on our own and so doing a group PBL study would be of little relevance...Before this semester I had no awareness of the importance of working collegially, and thought that most of the time, teachers didn't collaborate very much or discuss issues with one another. This was the opposite to when I went out on Practicum, and I witnessed teachers working as groups instead of individuals, and this deepened my level on understanding of the profession, and the methods that are used. So throughout this subject, the main thing that I learned about in relation to professional understandings is how to work cooperatively while respecting difference. I felt I witnessed a lot of this, and experienced it more so by taking part in the PBL group presentations.

Practice in a supported environment

Students 11 and 12 take the important step of beginning to reconceptualise their identity from student to teacher.

Student 12 The PBL unit was valuable in that it has given us the opportunity to begin conducting ourselves as teachers; it has helped me to begin to identify myself as a professional in the field and this has had a significant impact on my life.

Student 11 As a person who has begun their professional journey, I have found that I have learnt several aspects from undertaking the PBL approach.

Professional Collaboration

Personal development benefits of collaboration

Many students wrote that the PBL experience led to the development of their collaborative learning capabilities, such as Student 1, who recognised the growth in her collaborative skills and who is working on taming her perfectionism

Student 1 I signed up for the PBL classes specifically to try Problem Based Learning. And yet I must confess to having some reservations about PBL early on. You can see in my journal that as early as week 2 I had some problems coping with others ... PBL has challenged this and helped me become a better group/collaborative worker/learner. In all I'd place this at the top of what I've gained from the PBL approach...I have noticed amongst other teachers, and myself, that there is a strong inclination towards megalomania, along with a sense of individualism. It is, it seems, very easy to just work alone as a teacher, and even get to the point where one is protective of working alone. A focus on group work during professional development then is important. I've learnt to cool my megalomania a little, and been able to cope with others doing work (I get a little perfectionist).

Learning benefits of collaboration

Students 2 and 7 realised that collaboration has priceless benefits for building new knowledge:

Student 2 As the semester progressed, my knowledge and awareness of the personal, interpersonal and professional identities associated with teaching increased also, and I realized how relevant the PBL case study was to our learning. I found that working in groups was great, because it gave groups a chance to review all the material available. This is something that could not have been done as effectively on an individual basis, so by doing it as a group, everyone benefited and learned more as a result.... The benefits of doing this type of activity as a class of student teachers is priceless.

Student 7 The collaborative work that we have been doing has really helped to build my confidence in other group members, so much so that I feel confident with everyone going off on their own tangents and then coming back as a group and reporting their findings. I think this is a good thing because, it has really shown that if we divide the work up, we are still able to learn a lot. It has also shown me that teamwork can be so informative.

Practice benefits of collaboration

The authentic case studies had the effect of ‘opening the eyes’ of some students about the need to collaborate with the various members of school communities

Student 5 The case study on “Alex” opened my eyes to teachers having to work with parents, even if they disagree with them.

Student 7 PBL has really opened my eyes to the true value of professional collaboration, which I always knew was valuable, but not as valuable as this subject has shown me, it has helped me to better link theory to practice in a classroom setting, and I feel more confident in directing my own learning, both in finding information, and directing myself in the right direction.

Critical thinking

Links between PBL and personal schooling experiences

The case-studies and their associated readings prompted students to reflect upon their own schooling experiences, and to make comparisons and contrasts to contemporary theory and practice:

Student 3 Pat’s PBL task led me to do a lot of research on motivation and relationships (and in fact, as one can see from looking at week 2 and 3 [in my journal], it also led me to think a lot on my past schooling experience and the effect it will have on me as a teacher). Of particular note and interest to me on relationships was an article in the recommended readings for Pat’s PBL: Novak and Fisher’s ‘Seeing Student/Teacher Relationships as Hidden Dramas of Personal Development’. One of my favourite quotes to date came from there: “It is surprising and somewhat discouraging how little attention has been paid to the intimate nature of teaching and school learning...” – Jerome Bruner (1996)”. I like that: the intimate nature of teaching.

Student 4 The research into peer relationships I have undertaken during the PBL experience has allowed me to link my personal experiences of peer relationships with my new understanding of the emotional, social and academic effects of sociometric group membership.

Student 14 Reflecting on my experience throughout school, up until studying the... course, I had not taken into account how much of a considerable impression those who taught me had left upon me. They have all helped me to change, grow and develop as the person I am today.

Student 16 My school days were spent in a teacher centered learning environment isolated at my little desk.. I can assume that I was considered to be a ‘blank slate’ which suggests a strong influence of behaviourist theories... In my primary school days I may have appeared to be a passive learner. Unfortunately there wasn’t much choice. Negative reinforcement like public humiliation, “a cot for the baby” or “group bullying” taught one how to behave for survival. But, given different teaching, different possibilities present themselves.

Developing reflective practice

A major component of our PBL design was for students to maintain a reflective journal. From students' evaluations, it appears that there is some appreciation of the value of reflection for cognitive growth. For example, Student 8 is developing, through the opportunity for reflection, an appreciation of the ill-defined nature of social issues; Student 11 recognises that reflection is permitting her to make the necessary links between theory and practice; and Student 13 recognises that through reflective practice she is engaging in a process of self-development.

Student 8	I had previously encountered the PBL approach during my science studies where there was often a specific solution to the case. Consequently I was initially frustrated with the broadness of solutions and viewpoints from which the education cases could be handled. However, after reflecting on the readings and presentation of other groups I understand that there is never just one answer to student problems, particularly because they involve a network of social, emotional and cognitive demands.
Student 11	I have found that I have learnt several aspects from undertaking the PBL approach. My nature has become more reflective and I am only beginning to comprehend the connections between theory and practical application.
Student 13	One of the major purposes of DLT was to learn the art of reflective and analytical journaling, something that I found exceptionally useful in my first semester of a brand new degree. Through the journal I have examined my own beliefs about teaching and learning as well as my personal values, and have done so in a constructivist context, whereby I have formed '...my own representations of the material to be learned' (Dart et al 1998, p.293). In this sense, this course could have been called 'Self Development, Learning and Teaching'.

PBL and self-directed learning (SDL)

Personal development, learning and motivational benefits of SDL

Students 6 and 7 appear to be shifting their mental models about teaching and learning away from a transmissionist perspective towards a constructivist perspective. And both are discovering improved motivation to learn in a more self-directed paradigm:

Student 6	In my journal week 5 I said that I was not quite sure if I liked the idea of self-directed learning (SDL). This was because I was used to learning facts from the teacher or textbook. I like to be told what needs to be done and how to do it. However just like my journal entry for week 14 says I will try to implement SDL into my classroom as this constructivist methodology has grown on me over the semester. I like SDL because every student gets out whatever they put into it. This way students need to be working all semester so they understand the subject. Also, once work is complete a sense of self worth and pride comes upon you as you have done all the work yourself. For example in our final case study our group put a lot of work into our presentation because we picked a theme that interested all of us. I believe that all learning approaches have involved SDL and have encouraged me to work both independently (journals) and collaboratively (PBL and case studies). I no longer believe that you are able to use one methodology for one class.
Student 7	So the teacher isn't there to give you direct instructions, rather the teacher gives you the information you need, and will then only help to guide you through the process, meaning that the students are directly responsible for the direction they want to take. I really enjoyed this aspect of PBL, because I meant that I had to become involved in the project, I couldn't just sit back and have everything handed to me, I had a say in what I wanted to do and how I wanted to do it, which was a welcome and complimentary change to the rest of the work I have been doing at university so far...because if I was able to focus my learning on some of the areas that I was more interested in, because I was learning what I wanted to learn, I was able to take a lot more in.

Student 17 discovered the advantages of the PBL group work for learning and for feelings of personal achievement, and Student 15 recognised that the process of PBL developed her confidence in a variety of professional qualities:

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- Student 17 Through the experience of PBL group work, I found group work is essential in a classroom because PBL provides varieties of learning opportunities, personal opinion and experiences to share, and expands our knowledge and skills. Moreover, we decided what we discussed and how we presented our group work by ourselves, so when I finished presentation I felt achievement!
- Student 15 The DLT subject has enhanced my social interaction skills through the use of group work, class discussions, oral presentations, and the final tutor interview session. These strategies have enhanced my confidence and my ability to communicate valid and well researched ideas to a small and large group setting... This teaching strategy successfully compliments my learning style. I believe that this method of teaching has developed my ability to be a self-directed learner as well as dramatically improved my problem-solving capabilities. ... The structure of the subject has developed my ability to work collaboratively and cooperatively in group situations as well as individually. Foremost the subject has increased my ability and confidence in myself as a learner and as a future educator.
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Lifelong learning

Some students recognised that they are on a learning journey:

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- Student 9 As a person who has begun their professional journey...
- Student 14 Teachers must continue to learn and develop as quickly as they teach to continually be successful at teaching others.
- Student 15 Overall, this topic has reminded me that I will never stop being a learner and that I should continue to reflect upon my learning so that I can develop into a teacher that truly is a genuinely positive role model!
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PBL and building new knowledge

Increasing knowledge

Student 9 linked the PBL processes, specifically the case studies, to unexpected, and by his own account, surprising, growth in his knowledge about the various influences upon child development:

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- Student 9 I began the semester with the mindset that I would be clarifying the prior knowledge I had already gained. I was surprised by the amount of knowledge I was able to acquire about a child's development, learning strategies and the role of a teacher. The concept of problem-based learning (PBL) was not new to me, but I was able to develop my use of this process more effectively. I was able to comprehend to a greater extent the cognitive, social, emotional, moral, and physical developments of a child and how they were connected (Slee 2002), through the use of the PBL case studies. In researching each of these aspects I was astounded by the influence that family, culture and religion had on a child's development. Whilst it was expected that they would have some influence, it was beyond my initial comprehension the significance that diversity does have. I am very conscious now of considering such factors as divorce, peer relationships, and how a child perceives their environment.
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Strategies for teaching and learning

An account of steps in a problem solving procedure, and the outcomes of having the opportunity to work through those steps, are recognised by Student 11 as being valuable teaching-learning experiences.

Student 11 Through the use of PBL I have experienced the active role of solving problems. I have been required to identify the problem, consider alternative perspectives, select/justify solutions and consider the consequences. This has allowed me to develop reflective practices, an understanding of contexts, appreciation of teaching complexity, professional beliefs and values, and an awareness of cultural diversity. I have received many benefits from this form of learning. These benefits include: personal autonomy, control of one's learning, effective communication skills and a tolerance of ambiguity (Brady 2003).

Summary and future directions

The content analysis identified descriptors of change in all 105 participants' manuscripts. In addition, of the sample of 17 transcripts analysed in-depth, all 17 contained statements that could be placed into one or more of the categories of the conceptual framework, indicating that participants were developing new mental models about teaching and learning specifically as a result of their engagement in PBL experiences. Thus the results presented in this paper suggest that teacher education students do perceive that their PBL experiences contribute to their forming new perspectives about the issues that are at the core of professional training, namely theory-practice relationships, professional collaboration, critical thinking, self-directed learning and knowledge building.

Clearly this study reports pre-service teachers' perceptions, and in some cases, stated teaching intentions, but not participants' actual teaching actions. It may be the case that students espouse intentions that they will not follow through in teaching plans and actions. However, returning to our initial premise that knowledge predicates intentions that in turn predicate actions, the reports of students in this study suggest that students' PBL experiences have been informative in a way to positively influence their mental models. An important follow-up study will be to track the teaching actions of teachers who were exposed to PBL during their teacher education.

A second potential limitation of this study is that we only had access to the reflections of students who volunteered to contribute to our research. It may be the case that students who did not agree to the use of their manuscripts reflected upon their PBL experiences differently to our participant group. However, our sense from reading all students' manuscripts for assessment purposes is that the manuscripts included in the data base for this study were typical of the student cohort. The manuscripts also reflected the range of comments found in the Students' Evaluations of Topic that were collected as part of our university's regular topic evaluations.

Research into teachers' work has highlighted the importance of attending to the content of teachers' discussions about, and reflections upon, students, subject-matter, and teaching-learning actions (e.g. Horn, 2005; Little, 2003; Uline, Tschannen-Moran, & Perez, 2003). The analysis of teacher education students' reflective writing herein continues this work, drawing attention to the mediating influence of participants' mental models upon their understandings and intentions. This has the potential to inform the design of instructional programs, in this case, to make the argument that the PBL teacher education program provides students with learning experiences that do precipitate changing mental models, in line with contemporary theory, about classroom teaching and learning.

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