The interplay between theory and practice: Mathematics pre-service teachers' learning experiences at a teaching school[1]

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ABSTRACT

South Africa has insufficient pedagogies in teacher education that integrate pre-service teachers' experiences of theory at universities with their practical experiences in teaching schools (TSs). This paper examines mathematics pre-service teachers' learning experiences at a TS converging on the interplay between theory and practice. A three-level model proposed by Korthagen (2010), consisting of a gestalt-, schema- and theory-level, which built on the situative perspective, was used to frame the study. A case study using a qualitative research design was adopted with two data collection methods, namely, interviews and reflection reports. A sample of five mathematics pre-service teachers (PTs) enrolled for a Postgraduate Certificate in Education (PGCE) qualification, was purposefully selected. The results indicate most PTs could act and reflect on gestalt-driven experiences, however, an appropriate theory-level was not reached. At the gestalt-level most PTs viewed mathematics as abstract, theoretical and complex, and considered the teaching and learning of mathematics to be skill-driven. At the schema-level three PTs applied mathematics to real-life activities and reflected and acted intentionally in the teaching-and-learning process. At the theory-level all PTs coherently arranged some of their knowledge and considered the impact of their teaching on learners. The study contributes by providing a context to investigate the interchange between theory and practice.

Keywords: Mathematics, pre-service teachers (PTs), teaching school (TS), learning, theory, practice

INTRODUCTION

Worldwide there is a plea for reforming curricula focusing on teacher development (Ball & Forzani, 2009; Darling-Hammond, 2016; Department of Education (DoE), 2011; Furlong, Campbell, Howson, Lewis & McNamara, 2006; Lynch, Smith & Menter, 2016). In April 2011, the South African DoE released a technical report, *Integrated Strategic Planning Framework for Teacher Education and Development in South Africa for 2011-2025*, which highlighted challenges being experienced in teacher education. A lack of opportunities for prospective teachers and the failure of the system to achieve dramatic improvement in the quality of teaching and learning in schools were stressed. To meet these challenges, the report aimed to make 'institutional arrangements for the delivery of key components of teacher development such as a network of viable, accessible Teacher Education Institutions (TEIs) [and] Teaching Schools' (DoE, 2011: 3). Against this background, a particular university was approached by the DoE to conduct a study on the establishment of Teaching Schools (TSs).

In South Africa and in particular at the university under investigation, the teacher education programme for the Postgraduate Certificate in Education (PGCE) qualification is delivered predominantly in a theoretical mode consisting of formal lectures for 19 weeks. Practice, in the form of work integrated learning (WIL), is offered at schools only for short blocks of time during the year, namely three weeks in the first semester (March) and seven weeks in the second (August-September). However, theory and practice are offered as separate entities with limited integration, and theory-taught mathematics competencies do not contribute to better teaching practices (Lave, 1988). An integrated course has one curriculum that includes both theory and practice, which is jointly designed by the university and the TS. Furthermore, the course is delivered cohesively at one site, namely the TS. The course is also regulated by a specific set of guidelines determined by both partners.

The university has a responsibility for ensuring that its teacher education programme for mathematics pre-service teachers (PTs) is of high quality. The programmes should also lead to meaningful learning in the teaching of the subject. However, several PTs have informally complained that theory offered in the mathematics methodology modules is not relevant to what is expected in practice. Therefore, the university needs to 'implement innovative mechanisms to strengthen the work integrated learning component of the teacher education programme through the effective use … of teaching schools' (DoE, 2011: 3).

There have been investigations into the role TSs could play in the preparation of teachers for practice (Furlong et al., 2006; Tuovinen, 2008). Furlong et al. (2006) analysed formal partnerships between Higher Education Institutes and local schools in England, while Tuovinen (2008) examined the Finnish education system. However, none of these were devoted to the training of mathematics teachers within a South African context.

The study contributes to research on the training of mathematics PTs at higher education institutes. The exposure of mathematics PTs to practices in TSs may close the gap between theory and practice. The utilisation of TSs could lead to further changes in policy pertaining to the delivery of PGCE qualification programmes. Changed teacher education policies may, in turn, improve the quality of teaching and learning of mathematics in schools.

This paper reports on a pilot study that contributes to a broader study on the establishment of TSs to prepare secondary school PTs in various school subject specialisations for the profession. It specifically focuses on mathematics students' learning experiences displaying an interplay between theory and practice at a TS. The question arising from the above was thus: *What learning experiences of PGCE mathematics PTs at a TS display an interplay between theory and practice?*

Pre-service teacher (PT) education with specific reference to teaching schools in other countries is examined through a literature survey. The interplay between theory and practice in learning will be explored by means of a three-level model conceptualised by Korthagen (2010). Thereafter, the research methodology, which uses an exploratory qualitative case study, is discussed. Results follow from the data analysis process and the findings are discussed.

PRE-SERVICE TEACHER (PT) EDUCATION IN OTHER COUNTRIES

There is a need for innovative approaches to improve the quality of teacher education in South Africa (DoE, 2011), especially in preparing mathematics PTs for the profession. One therefore needs to draw on the successes in teacher education of other countries with similar programmes.

Historically, PT teacher education in England was theory-driven and mostly offered by universities (Hodkinson, 2008). From the mid-1980s the control of teacher education moved to the central government's Department for Education, which established stronger partnerships between universities and schools to ensure better alignment between theory and practice. From 1992 it has been a requirement that teacher education be conducted through formal partnership arrangements between individual Higher Education Institutes (HEIs) and local schools (Furlong et al., 2006). England uses three ideal models of partnership in practice (Furlong et al., 2006). First, *complementary* partners see the university and schools having separate and complementary responsibilities, not necessarily integrated in the teaching programme. Second, *collaborative* partners focus on an educational programme developed together by teachers from schools and lecturers from HEIs to align theories and practices in teaching. Third, *resource* partners have education programmes led by HEIs with inputs by a small number of teachers, acting as consultants. While there is substantial international interest in such partnerships by countries, such as the United States of America, Australia and New Zealand, they have only become institutional at a national level in England and Wales (Furlong et al., 2006).

Successes were also drawn from the Finnish education system. According to the Programme for International Student Assessment (PISA) this system had a ranking of two in a mathematics literacy test in 2006 (Tuovinen, 2008). As in England, universities in Finland utilise *collaborative* partners. Pedagogies and practice teaching are conducted throughout the entire duration of the teacher education programme within TSs, as 'schools in which a major part of student pedagogical practice is conducted are linked organically with the departments of education' (Moon, Vlasceanu, & Barrows, 2003: 89). These are local schools consisting of supervising teachers contracted by universities to specialise in the supervision of PTs, by guiding teaching practice, developing pedagogy and assisting with curriculum planning. TSs integrate teaching practice into all levels of teacher education, from the beginning to the end of the studies. Thus, TSs are teaching laboratories, where PTs can engage in learning-from-practice, such as observing best practice, participating in micro-teaching exercises and taking subject methodology courses.

THE INTERPLAY BETWEEN THEORY AND PRACTICE IN LEARNING: A THREE-LEVEL MODEL

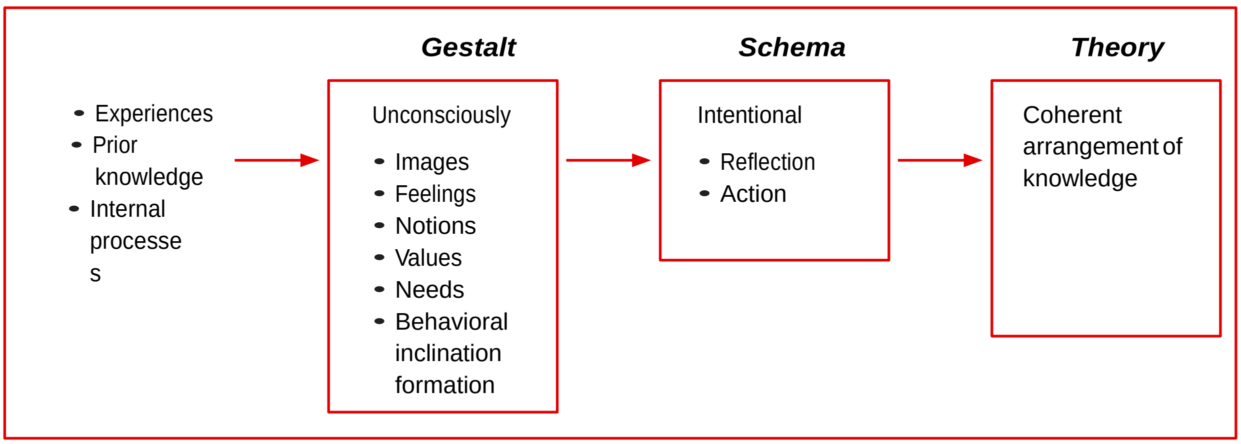
Learning in any situation, including TSs, is multifaceted. Learning to become mathematics teachers not only happens when knowledge is transferred in a theoretical mode by teacher-educators. Learning also occurs during practical situations, as PTs interact with mentor teachers. Several researchers (Lave & Wenger, 1991; Greeno, 1998; Brodie & Sanni, 2014) agree that learning is located in the context in which it transpires, is communally created and emerges from a person's own actions in relation to those of others. PTs memorise, symbolise and develop mathematical concepts in relation to each other while situated in a social world. These concepts are 'strongly informed by and even bounded by their practice… [and] constrained and afforded by practice' (Brodie & Sanni, 2014: 188).

PTs learn to become mathematics teachers not only by learning educational theories and complex concepts. They also have to act in the teaching-and-learning process. In particular, they become skilled through a process of participation and enculturation in social practices in schools (Lave & Wenger, 1991). Learning further happens through experiences and role modelling of teacher-educators who can explain and transfer knowledge well. A challenge is to merge learning via traditional cognitive theory and situated learning. Cognitive theory refers to the unfolding of the features of 'knowledge and knowledge development', while 'situated learning explain the role of embodied social learning' (Korthagen, 2010: 99).

There are reservations about the effectiveness of teacher education that could be ascribed to a division between theory and practice (Korthagen, 2010). Universities often perceive teacher education from the outside, unaware of the inner dynamics or expectations within the school context. PTs' work integrated learning at schools occurs in a short time and they seldom get the opportunity to enculturate within the community of practice at schools where much learning is taking place.

Korthagen (2010) proposes a three-level model (Figure 1), built on the situative perspective. This viewpoint aims to analyse the conflict between teacher approaches in practice and the grounding of teachers' practices into theory. The model shows that knowledge has its origins 'in practical situations and is socially constructed, but that there is a difference in how knowledge can be used' (Korthagen, 2010: 102).

Figure 1:
The three-level model and the accompanying learning process



(Adapted from Korthagen, 2010: 100)

In the *gestalt*, which is the first level, PTs' previous experiences, prior knowledge and internal processes of learning are intertwined. A gestalt refers to the 'intrapersonal and psychological counterpart of the social process of situated learning' (Korthagen, 2010: 100). A *gestalt* or percept is formed in the mind, which has 'properties that are different from those of its parts' and cannot be described as a sum of its parts or 'defined only by some isolated features' (Hamburger & Röser, 2011: 363). The mind recognises complete pictures visually, instead of merely sets of unconnected features such as lines, borders and curves. PTs sometimes instinctively project their way of learning mathematics onto their learners without being aware of it and are unconscious 'of the effects of their behavior and its underlying causes' (Korthagen, 2010: 101). Unintentional, temporary responses generate 'images, feelings, notions, values, needs or behavioral inclinations, and often ... combinations of these factors', which are interwoven and form a whole, called a *gestalt* (Korthagen, (2010: 101). The concept relates to a person as an individual in totality (Lave & Wenger, 1991), intertwined with the social contexts in which *gestalts* are produced. The implied learning happening during the process of *gestalt* formation is known as the development of awareness of learning and is not so much considered as conceptual development (Korthagen, 2010).

PTs may become aware of some parts of their *gestalt* after reflecting. This awareness could lead to certain conclusions, and form the second level, namely the *schema*. Procedures, ideas and/or theories become interconnected during the reflection process and action may be taken. PTs may link their teaching with prior cognitive schemes, such as prior knowledge or experiences of learning. An earlier unintentional *gestalt* develops itself into a conscious cognitive *schema* at this time, which is an important next level in the learning process. When PTs reflect on a situation and actions are taken in the particular or similar situation, they may develop a schema, which consists of a mindful network of ideas, features and values assisting in explaining practice. The 'transition from the *gestalt* to the *schema*-level is one of de-situating the knowledge derived from specific situations, [namely] situated generalisation' (Korthagen, 2010: 102).

The last level, namely the *theory*, is characterised by the development of a more theoretical understanding of a variety of related circumstances. This is the level on which a coherent arrangement is created in the knowledge built previously. The *theory*-level aims to establish a profound and broad understanding of a range of related situations (Korthagen, 2010). Numerous schemata are linked into one comprehensible theory.

RESEARCH METHODOLOGY

A situative perspective was adopted to highlight the interplay between theory-driven lectures on mathematics teaching at the university and real-life contexts in the TS (Anderson, Reder & Simon, 1996). A situative perspective provides a view to analyse teaching and learning practices in any setting (Greeno, 1998). An exploratory qualitative case study approach was chosen, allowing for investigating a complexed phenomenon within a specific context using various forms of data (Baxter & Jack, 2008). This study situated in a TS envisages to gain rich insights into the interplay between theory and practice by exploring PGCE mathematics PTs' learning experiences.

A purposeful sampling technique (Creswell, 2014) was used. Five mathematics PTs from a population of 15 enrolled for a PGCE mathematics qualification at the selected university participated voluntarily.

The TS was chosen for its proximity of about five kilometres from the university and easy access for students between the university and the TS. All participants enrolled full-time for the qualification and had no prior teaching experience. There were three males and two females.

One-on-one semi-structured interviews were conducted with PTs before, during and after the project and 11 written reflection reports were submitted over a period of 25 weeks. The interplay between theory and practice cannot be established within a short period of time, therefore, the pilot study's duration was spread over a period of five-and-a-half months. The broader study envisages to expose PTs specialising in various subjects to a TS for their full period of study, namely one year. PTs' responses were elicited by means of the following questions:

- What are your views pertaining to the teaching and learning of mathematics? Why? (Interviews 1–3; Reflections 1, 6. 11)
- What, if any, learning experiences have you encountered at the TS so far pertaining to your development as a teacher? Explain. (Interviews 2–3; Reflections 2–11)
- What, if any, challenges have you experienced so far at the TS? How did you address them? (Interviews 2–3; Reflections 2–11)
- How have you developed professionally as a teacher? Elaborate. (Interviews 3; Reflections 11)
- How do you see the interplay between theory offered at the university and your teaching practices at the TS? (Interviews 1, 3; Reflections 1, 11)

To ensure trustworthiness, the researcher adhered to scholarly rigour, transparency and professional ethics (Rule & John, 2011). The research question, as outlined in the introduction of the study, was used to frame the development of the interview questions. Critical peer checks were conducted by showing interview questions and interpretation of data to colleagues for comment and suggestions to ensure clear conceptualisation. Member checking with participants confirmed the accuracy and completeness of the emerging findings and contributed to the credibility of the study. An audit trail allowed for the findings to be traced back to the data. Thick descriptions of the case, direct quotations from the data and literature support guaranteed a level of transferability of the findings. Triangulation was employed to control the data obtained from the interviews with that attained from the reflection reports for accuracy. Questions were repeated in both the pre-, middle and post-interviews and the reflection reports until data saturation was obtained. Triangulation by using multiple sources also allowed for new facets to emerge (DePoy & Gitlin, 2011), thus crystallisation. Dependability was addressed by 'employing rigour and coherence towards generating findings' (Rule & John, 2011: 107). To minimise researcher's bias, the limitations of the study were stated. Ethical measures were also taken into account ensuring confirmability.

Participation was voluntary, consent obtained and the anonymity of the participants protected (Mouton, 2001). The Research Ethical Committee of the Faculty of Education granted clearance for the study. Furthermore, informed consent was obtained from the participating TS. The TS is an affiliated high school to the Faculty of Education of the university. GDE has rendered the university authorisation to conduct research at the school.

RESULTS

The interviews were audio-recorded and transcribed and the data analysed by reading the transcriptions and reflection reports thoroughly in order to obtain a holistic perspective. Thereafter irrelevant data were removed. Words and short phrases were coded qualitatively using open coding (Saldana, 2009). Sub- categories were derived and grouped into specific categories. Thereafter, recurring themes of views about the nature of mathematics and pedagogical content knowledge (PCK) were identified. The development within the themes from the *gestalt* to the *schema* and finally to the theory-level (Korthagen, 2010) was deductively analysed.

The results of the analysis are presented firstly with regard to views about the nature of mathematics, then pertaining to PCK. For each of these two themes a summary table is provided that indicates the number of participant utterances in the interviews and the reflection reports across Korthagen's (2010) three levels. The first five columns of figures in each table indicate the frequency (*f*) of utterances for each participant, while the last column (*N*) refers to the number of participants (out of 5) who referred to the category. After the tables, qualitative analyses of the participants' responses follow structured by the identified sub-categories and Korthagen's (2010) three levels. Participants are referred to by alphabetical letters to protect their anonymity.

DISCUSSION

Results of the analysis with regard to views about the nature of mathematics

Ernest (1991) advocates three beliefs about the nature of mathematics. A Platonist views mathematics as *minds-on* and theoretical. An instrumentalist believes the subject is *hands-on* and skills-orientated, while an experimentalist embraces mathematics to be *hearts-on* and human-focused. Beswick (2012) elaborated by classifying these beliefs in terms of mathematics teaching and learning. Platonists teach abstract mathematics content focusing on learners' understanding. Instrumentalists teach procedural mathematics emphasising the execution of mathematics. Experimentalists teach real-life mathematics for all people to succeed. The researcher used these three views to analyse PTs' levels of development of their beliefs about the nature of mathematics in terms of the subject, teaching and learning.

All PTs noted beliefs about the nature of mathematics, which contributed to 51 comments across the development levels. However, 64.7% (33) of the comments were made at the *gestalt*-level, 15.7% (8) at the *schema*-level and 19.6% (10) at the *theory*-level. The beliefs also varied in terms of the subject, the teaching and the learning. Almost a third of the comments (31.4% (16)) focuses on the subject, a half (47.1% (24)) on teaching and the rest (21.5% (11)) on learning.

Table 1:
Categories and sub-categories on views about the nature of mathematics

Category	Sub-categories	*f* A	B	C	D	E	*N = 5*
Subject	*Gestalt*						
	Difficulty of mathematics	3	1	2	3	0	4
	Beliefs:						3
	• Platonist	0	2	0	0	1	
	• Instrumental	1	0	0	0	0	
	• Experimental	0	1	0	0	0	
	Schema						
	Beliefs:						1
	• Platonist	0	0	0	0	0	
	• Instrumental	0	0	0	0	0	
	• Experimental	2	0	0	0	0	
	Theory						
	Beliefs	0	0	0	0	0	0
Teaching	*Gestalt*						
	Beliefs:						5
	• Platonist	1	1	1	1	3	
	• Instrumental	0	0	1	1	0	
	• Experimental	1	0	2	0	0	
	Schema						
	Beliefs:						3
	• Platonist	0	0	0	0	0	
	• Instrumental	0	1	0	1	0	
	• Experimental	2	0	0	0	0	
	Theory						
	Beliefs:						5
	• Platonist	0	0	0	0	0	
	• Instrumental	0	0	0	0	0	
	• Experimental	3	2	1	1	1	

Category	Sub-categories	*f* A	B	C	D	E	*N = 5*
Learning	*Gestalt*						
	Beliefs:						4
	• Platonist	1	0	0	0	0	
	• Instrumental	0	0	0	2	0	
	• Experimental	2	0	1	0	1	
	Schema						
	Beliefs:						2
	• Platonist	0	0	0	0	0	
	• Instrumental	0	1	0	0	0	
	• Experimental	0	0	1	0	0	
	Theory						
	Beliefs:						3
	• Platonist	0	0	0	0	0	
	• Instrumental	0	0	0	0	0	
	• Experimental	0	1	0	1	1	

(a) The subject

Initially, four PTs referred to the difficulty of mathematics. Three viewed mathematics as easy, but acknowledged that people perceive it as difficult because of their previous experiences with the subject. The other acknowledged the difficulty of the subject could change by putting more effort into it. Although three PTs had thoughts about the nature of mathematics in terms of the subject at the *gestalt*-level, only one developed at the *schema*-level. The PT who originally upheld an instrumental belief, arguing mathematics is not only theory but about doing something, developed an experimental belief:

> that it's very important that teachers make abstract ideas to everyday reality (A, Interview 1, Aug).

This belief is in agreement with Ernest's (1991) experimental belief considering mathematics as a practical subject allowing for real-life applications. Mathematics becomes more meaningful if it is related to real-life applications, even though it is not always easy. PTs would be better equipped if they understand the nature of the subject.

(b) Teaching

With regard to the teaching of mathematics, all five PTs had initial thoughts on teaching, which they could eventually link with theory. Originally they held a Platonist belief about the teaching of mathematics at the *gestalt*-level focusing on teaching theory for understanding (Ernest, 1991).

All PTs changed their beliefs at the *theory*-level to an experimental belief by adopting a heuristic approach towards the teaching of mathematics. They could have arranged subject content to real-life applications and involved learners in their teaching. However, only three PTs could act on their beliefs at the *schema*- level:

> ...something that can be worked on, the matter of communicating (A, Interview 2, May).

> It made me realise it is all about you must think on the spot, it is very challenging (B, Interview 2, May).

> You do it step by step according to a lesson plan, it is not all at once (D, Interview 2, May).

According to Beswick (2012: 128) PTs' beliefs about the nature of mathematics should combine mathematics knowledge and mathematical pedagogy, known as 'mathematical knowledge for teaching'. Once PTs can align their content knowledge with their teaching practices they will develop a coherent understanding of the nature of mathematics. Experience in teaching has the greatest influence on change of beliefs about the nature of mathematics (Beswick, 2012).

(c) Learning

Four PTs were oblivious to ideas about the learning of mathematics at the *gestalt*-level. One had a mix between Platonist and experimental beliefs but had not developed further. One held an instrumental belief but developed to an experimentalist at the *theory*-level, admitting people should learn from each other. The other two had experimental beliefs which continued respectively at the *schema*-level and at the *theory*-level by relating their beliefs to a constructivist learning theory. The PT without any initial thoughts could however intentionally act at the *schema*-level:

> I ask students to verbally repeat the information as a whole-class. These types of activity help students [to] process information in working memory (B, Reflection 9, Jul).

This engagement concurs with Beswick's (2012: 130) instrumental belief about mathematics learning, namely, 'skill mastery, passive reception of knowledge'. The same PT changed to become an experimentalist at the *theory*-level emphasising learner involvement:

> Anything that captures students' attention and engages their mind has the potential to produce learning. Of course, the opposite is also true: No attention, no engagement, no learning (B, Reflection 9, Jul).

Yet, none of the PTs developed through all three developmental phases. From the above it is evident that the *gestalt*-level includes PTs' existing views and thoughts about teaching mathematics before reflection and action (Lave & Wenger, 1991). Once being exposed to the TS, some PTs began to verbalise their experiences, intentionally acted in the teaching-and-learning process and even started to provide reasons for their actions.

Results of the analysis concerning pedagogical content knowledge (PCK)

Shulman (1986) coined the concept of pedagogical content knowledge (PCK), comprising a mixture of subject matter knowledge and pedagogical knowledge. PCK also implies knowledge of teaching methods, assessment, classroom management, lesson planning and knowledge of learners influencing teaching and learning (Akhtar, Shaheen & Bibi, 2016). Pino-Fan, Assis, and Castro (2015) add additional dimensions to PCK, namely mediated facets including resources, ecological facets comprising contexts and a meta- didactic mathematical facet embracing teachers' reflections on their teaching. The researcher utilised all these elements of PCK to analyse PTs' levels of development in this regard.

All PTs indicated PCK elements (142 utterance) across the development levels (Table 2). The weightings of the utterances were 4.2% (6) at the *gestalt*-level, 63.4% (90) at the *schema*-level and 32.4% (46) at the *theory*-level. The majority of the utterances focused on pedagogy (44.4% (63)), followed by professionalism (17.6% (25)) and knowledge of learners (10.5% (15)). Other PCK elements with smaller weightings were resources, assessment, classroom environment, content and reflection.

Table 2:
Categories and sub-categories on views concerning PCK

Category	Sub-categories	*f* A	B	C	D	E	*N = 5*
Pedagogy	*Gestalt*						
	Knowledge of teaching methods	1	0	0	0	0	1
	Schema						
	Knowledge of teaching methods	4	3	5	5	3	5
	Lesson planning and presentation	0	2	2	2	3	4
	Theory						
	Definition of PCK	2	1	1	0	1	4
	Motivation for good PCK	0	1	1	0	0	2
	Ways to improve PCK	1	0	1	1	1	4
	Advice on preparing lessons	0	1	2	2	1	4
	Purpose of a lesson plan	0	2	3	3	5	4
	Alignment of theory and practice	0	0	1	2	0	2
Content knowledge	*Gestalt*						
	Thoughts about knowledge	1	0	0	0	0	1
	Schema						
	Improved content knowledge	0	2	1	0	1	3

	Theory						
	Theorise content knowledge	0	0	0	0	0	0
Knowledge of learners	*Gestalt*						
	Inability to do mathematics	0	1	2	0	1	3
	Schema						
	Background	1	0	2	1	0	3
	Language challenges	0	0	1	2	0	2
	Theory						
	Accommodate learners in lessons	2	0	1	0	1	3

Category	Sub-categories	*f* A	B	C	D	E	*N = 5*
Classroom environment	*Gestalt*						
	Thoughts about classroom	0	0	0	0	0	0
	Schema						
	Effective classroom environment	3	0	1	1	1	4
	Theory						
	Theorise importance of classroom environment	0	0	0	0	0	0
Assessment	*Gestalt*						
	Thoughts about assessment	0	0	0	0	0	0
	Schema						
	Conducting assessment	1	0	3	0	4	3
	Theory						
	Process of assessment	0	2	0	0	1	2
Resources	*Gestalt*						
	Thoughts about resources	0	0	0	0	0	0
	Schema						
	Use various resources	2	0	0	2	5	3
	Practice with resources	1	0	2	0	0	2
	Theory						
	Theorise the use of resources	0	0	0	0	0	0
Reflection	*Gestalt*						
	Thoughts about reflection	0	0	0	0	0	0
	Schema						
	Importance of reflection	1	1	1	0	0	3
	Reflection is challenging	1	1	0	0	0	2
	Theory						
	Theorise the role of reflection	0	0	0	0	0	0

Category	Sub-categories	*f*					*N = 5*
		A	B	C	D	E	
Professionalism	*Gestalt*						
	Thoughts about professionalism	0	0	0	0	0	0
	Schema						
	Relationships	1	0	0	2	0	2
	Appearance	1	1	0	0	0	2
	Discipline	0	0	3	1	1	3
	Respect	0	1	0	1	1	3
	Time management	1	1	1	0	0	3
	Theory						
	Development of professionalism	1	0	1	0	1	3

(a) *Pedagogy*

Only one PT developed through all three levels pertaining to knowledge of teaching methods. At the *gestalt*-level, the following thought was shared:

> you have to teach it … your learners should be able to understand what you talking about … probably they can relate to it in terms of applying (A, Interview 1, Feb).

Conversely, all five PTs could provide ideas based on reflection on how to teach mathematics at the *schema*-level. Some of the suggestions to teach for understanding were:

> asking them questions in relations to their day to day activities … I explain to the learners' basic method
> … they quickly started to guide me through the steps … they could now do problems themselves (A, Reflection 9, Jul).

> let the learner do it themselves (A, Interview 3, Aug).

> linked new information to the student's prior knowledge … to verbally repeat the information as a whole-class (B, Reflection 9, Jul).

> [teach] with the end in mind (D, Reflection 9, Jul).

> you'll do an example first … you will do the exercise and practise (D, Interview 3, Aug).

The findings are in agreement with Wilson, Cooney and Stinson's (2005: 91) four characteristics of good teaching, namely 'the importance of prerequisite teacher knowledge, promoting mathematical understanding, engaging students, and effectively managing the classroom environment'. All PTs could also align their practices with theory at the *theory*-level. One PT pertinently referred to a learning theory:

> I apply [a] constructivist learning theory … I allow him to focus in thinking about

> learning and understanding mathematics. I also allow him to give a sensory input and to construct meaning out of it which encourage him to use active techniques, real world problem solving to create more knowledge and reflect on it (E, Reflection 9, Jul).

Theory plays an important role in the teaching and learning of mathematics, especially between transitioning from the *schema*-level to the *theory*-level. However, Korthagen (2010) warns that theory should only be introduced when a need for deeper understanding evolves.

No PT originally had views about lesson planning and presentation at the *gestalt*-level. However, four PTs could reflect on it at the *schema*-level after being exposed for a while to a TS. Some remarks were:

> I need to be ready for anything and questions from the learners ... I prepared … only to realise that I had to add other ways and methods which were not part of my plan to help students who did not understand (B, Reflection 3, Apr).

> The lessons must be short, relevant and understanding to the learners … The teacher must give an activity in the class relating to the topic … and homework must also be given (E, Reflection 4, May).

> A detailed lesson plan … made me visualise each class before I taught it. I imagined the flow from one activity to the next, made sure there was a balance of skills and types of activities, and anticipated places where we might detour from the lesson (B, Reflection 10, Aug).

This last utterance corresponds with Cavanagh and McMaster's (2015: 259) claim that PTs tend to plan a lesson as a linear sequence of unrelated events. Although the PTs knew what they wanted to achieve in their lesson presentation they did not incorporate learners' thinking. This finding is in agreement with Masingila and Doerr's (2002) observation that PTs encounter difficulty 'when trying to use student thinking and to follow their own mathematical goals in a lesson'. The same four PTs could also give advice on how to prepare and present lessons at the *theory*-level. Some suggestions were:

> [to] sequence and do the activities, move logically and learners are progressively building on what they already know (B, Reflection 10, Aug).

> Make sure the material and equipment you are going to use are available and in good working order a day before. Make a list of things you want to cover on a lesson. Allocate time that will be spend on each item in your list. Seating arrangements should also be noted … with the description of the class and learners … goals and objectives of the lesson should be listed and explained to the learners … When engaging with a new topic it's important to find the existing knowledge of the learners ... make sure you summarise your lesson at the end to find out whether the learners did understand and whether the goals and objectives were reached (C, Reflection 6, May).

> The first section will be introduction of the lesson. The middle section will give all of the important facts of the lesson. The last section will reinforce the main ideas, and the conclusion of the lesson (E, Reflection 5, May).

The four PTs could in addition logically provide the purpose of a lesson plan and the essence of lesson preparation. Examples of a few utterances are:

it acted as a road map for the presentation and sharing the objectives (B, Reflection 10, Aug).

A lesson plan … help you … to reflect in your teaching … know what to do and when to do what, it's a reminder of your goals and objectives of your lesson … It is also a record of what has been done in class … it also help to control class time affectively (C, Reflection 6, May).

Planning and preparing is necessary and helps greatly in the conducting of the lesson (D, Reflection 5, May).

This finding is in agreement with Cavanagh and McMaster's (2015) discovery that through reflective practices PTs could progress in lesson planning in terms of the achievement of learning objectives and the measurement of the impact of their teaching.

(b) Content knowledge

Very few utterance (4) were made pertaining to content knowledge of which one was made at the *gestalt*- level, namely:

their knowledge in class … this learners they don't get zero when you give them tasks (A, Interview A, Feb).

Examples of two reflections on content knowledge at the *schema*-level are:

My role as a student-teacher in a subject like mathematics is to ensure that I remain up to date with developments in my areas of expertise, and possibly to extend these (B, Reflection 2, Apr).

I have to know my content, must have a good content knowledge, so that I can pass it to learners … I must get their current knowledge and link it with the new knowledge that I am going to give them and again to make it more interesting for the learners to understand (C, Interview 3, Aug).

No PTs could coherently arrange their content knowledge at the *theory*-level. This finding is a concern, especially in the light of Wilson et al.'s (2005) claim that effective teaching is based on mathematical construction. However, one PT confessed:

When your PCK is very good, your lesson presentation will work out smooth and aims/objectives of the lesson can be easily achieved (C, Reflection 11, Aug).

The above-mentioned findings on pedagogy and content knowledge concur with Lim-Teo, Chua, Cheang and Yeo's (2007) observation that PTs are more concerned about teaching methods than correct mathematical content knowledge.

(c) Knowledge of learners

Two PTs unconsciously noted learners are unable to do mathematics. This thought was only evident at the *gestalt*-level. They claimed:

> you also want your child also to learn maths but he does not have the intellectualism of mathematics (B, Interview 1, Feb).

> the lack of understanding of the learners … a problem for them, to understand that Mathematics (E, Interview 1, Feb).

The other three PTs identified the importance of knowledge of learners in teaching at the schema-level. Some reflections provided are:

> know those kids … individually by their names and what their problems might be and the barriers that they have (A, Interview 2. May).

> you must be knowledgeable about the learners you are going to teach. You have to know their background (C, Reflection 11, Aug).

After reflecting, communication skills of learners were indicated as challenging:

> There is a barrier … with the language: the way students talk, the way they write, and when they have to now read a concept, and when they have to grasp it (D, Interview 3, Aug).

Participant A developed her knowledge of learners at the *theory*-level. She maintained a cognitive constructivist learning theory believing learners develop according to age:

> the age group I think sometimes makes a difference … that plays a bigger role try and get it to the level of the learner (A, Interview 3, Aug).

Wilson et al. (2005) agree that mathematics teachers should have an extensive knowledge of their learners. They added the importance of subject knowledge to teach effectively.

(d) Classroom environment

No PT had any thoughts about the classroom context at the *gestalt*-level or developed at the *theory*-level. However, four of them could reflect on it after exposure to a TS. One remark made is:

> Even someone who is not doing mathematics they should know this is a mathematics class, [a] stimulating environment (A, Interview 2, May).

Although Walshaw (2004: 75) argues that 'each classroom has its particular regime of truth that legitimises and sanctions a discursive space for certain practices and social arrangements', Wilson et al. (2005) emphasise that managing the classroom environment effectively is an aspect of good teaching.

(e) Assessment

At the gestalt-level no thoughts were shared about assessment. At the *schema*-level three PTs could reflect on how to conduct assessment. One PT reflected as follows on how her assessment practices had changed since her exposure to the TS:

> if I… test the learners the way I was tested, such assessment will encourage surface learning rather than deep or meaningful learning … there are some general principles teachers should keep in mind … like fairness, reliable valid … the assessment task need to be linked to the learning outcomes and does it give all learners equal opportunity to succeed … methods include peer assessment, self-assessment, and group assessment (B, Reflection 7, May).

However, the finding does not indicate that the PTs 'understand the reasoning that [a] teacher uses when eliciting student responses, asking probing questions, deciding on instructional materials, and assessing the quality of student work' (Masingila & Doerr, 2002: 236). At the theory-level, two PTs could intelligibly order the process of assessment and checked for compliance with assessment principles:

Before the assessment can take place, the assessor has to plan, design and prepare assessments. This includes making decisions about the method of assessment, the instruments to be used, the activities to be structured and the extent to which more than one learning outcome can be assessed simultaneously (B, Reflection 10, Aug).

> See if the task conforms to set assessment principles which are as follows: Does the assessment task clearly align with the curriculum? If the assessment is relevance to course learning to take place and if it has been made explicit to learners? Is the assessment task appropriate? Is the weighting of the task proportionate to the workload and level of complexity? (E, Reflection 7, May).

The finding indicates that PTs are more concerned about how assessment should be structured than 'assessing students' understanding as a means of shaping their instruction' (Wilson et al., 2005: 104).

(f) Resources

Initially, no thoughts pertaining to resources were conveyed at the *gestalt*-level. After exposure to the TS, four PTs realised they should use a range of resources to assist their teaching at the *schema*-level:

> The teacher must have a library of textbooks (A, Reflection 10, Aug).

> some of the teaching materials like the white boards … it needs a lot of practice there (C, Interview 3, Aug).

> It was not easy … using the textbook only … also do have access to other resources (D, Reflection 3, Apr).

> the textbook is not enough. It does not give enough theory (E, Reflection 3, Apr).

In addition, Wong, Chong, Choy, and Lim (2012) observed that PTs should know how to select appropriate resources to achieve lesson outcomes. Unfortunately, none of the PTs developed at the *theory*-level.

(g) Reflection

No PT had thoughts about reflection at the gestalt-level. At the schema-level three PTs realised the importance of reflection after gaining some teaching experience, but found it challenging:

I have realised … that teaching does not always proceed smoothly … it requires a teacher that think and reflect (B, Reflection 2, Apr).

it is a positive setting in which I can reflect on my practice (C, Reflection 2, Apr).

it appears as though it is easy … one is lacking the milestone travelled from the beginning of learning the practical experience, ability to reflect on delivery of content (pedagogy) and knowledge of actual content (A, Reflection 5, May).

PTs, however, could not theorise the role of reflection at the *theory*-level. Cavanagh and McMaster (2015) argue that reflection on teaching practices connects teacher actions with students' learning, which was regrettably not the case in this study.

(h) Professionalism

At the *gestalt*-level PTs had no initial ideas about professionalism. At the schema-level some PTs started acting and reflecting on different aspects of professionalism. Though classroom management was found to be challenging, three PTs could act on misbehaviour by taking action:

to be firm in my class and to tell the learners what I want … to send the learners out of the class (B, Interview 3, Aug). when you are well prepared you feel confident in front of the learners and when you are confident it's easy to manage your class (C, Reflection 10, Aug).

Planning of my lessons has also helped me in the classroom management, it makes my learners to be discipline in the class when I am presenting my lessons (E, Reflection 10, Aug).

Three PTs realised they had to conduct themselves professionally in order to deserve respect. Some reflections shared are:

know the boundaries in the school environment and dress accordingly (A, Reflection 4, May).

Professionalism needs to be maintained at all times. A set of healthy boundaries needs to be established with the learners. A sense of decorum is required from the teacher (D, Reflection 5, May).

To be professional, three PTs acknowledged they should manage their time properly when teaching. A few utterances made are:

It is the responsibility of every teacher to adhere to due date (B, Reflection 5, May).

It is important to come early in the class so that you just go through your lesson plan again (C, Reflection 4, Apr).

Only one PT viewed good administration as an important aspect of professionalism, but found the execution of it tedious:

> Administration is very important … it should be done correctly in a professional way … because it puts everything in order … If is not done at the beginning of the year it will pile up and becomes difficult to do (B, Reflection 4, May).

Lastly, two PTs realised to be professional, they should take accountability. One PT reflected:

> Teachers are responsible for the change that takes place in learners and their role as change agents (B, Reflection 1, Feb).

> As a teacher I have so much responsibility, for the learning to be effective … I realised this it's up to me whether the class is going to be effective or not (B, Interview 3, Aug)

At the *theory*-level, three PTs could develop a mindful network of ideas, features and values pertaining to professionalism, which assisted in explaining their practice. One PT acknowledged a convergence of interplay between theory and practice:

> One can now assess exactly the theoretical side of learning in practice and how do they meet, this enable student teachers to develop necessary skills when they go to schools (A, Reflection 10, Aug)

Cavanagh and McMaster (2015: 487) support PTs' realisation of the important role professionalism plays. They note that 'the ability to effectively manage student behaviour is often regarded by PTs as an indicator of their success as a teacher'. Wilson et al. (2005) agree good mathematics teaching requires effective classroom management to achieve learning goals, which includes time management, discipline, record keeping and lesson planning.

From the above discussion, it can be deduced that PTs developed 'from an initial pre-occupation with self to a focus on tasks and teaching situations, and finally to consideration of the impact of their teaching on their students' (Wong et al., 2012: 113). PTs could coherently organise some of their previous knowledge on teaching and learning of mathematics. The knowledge was built from PTs' own experiences and actions executed at the TS (Korthagen, 2010). They also developed a reflective understanding of a range of related situations. If measured against the five criteria of a good theory (Kuhn, 1977 as cited in Korthagen, 2010: 102), PTs have partially developed at the *theory*-level. Even though the data is accurate it is not complete. A wide range of data is elicited. In most cases it is internally consistent with other known theories, however, the findings are modest and the study has only produced a few new results. PTs cannot be forced to learn to become good mathematics teachers. They can only build understanding if they want to structure or change new knowledge into their current practices (Lave & Wenger, 1991).

The evidence from the results indicates that PTs tend to view mathematics more in terms of content knowledge and skills than acknowledging learner engagement in the teaching and learning of mathematics. Therefore, there are implications for practice within a TS.

First, the interaction between mathematics content knowledge, pedagogy and knowledge of learners should be blended. Beliefs about the nature of mathematics should be emphasised during teacher training. Mathematics content knowledge should be linked to real-life problems. PTs should receive formal training in communicative English with a focus on mathematics terminology. Furthermore, PTs should be exposed to teaching strategies involving learner-centred and problem-solving approaches where learners autonomously explore phenomena.

Secondly, PTs should start teaching several mathematics lessons as early as possible. In particular, they should be guided on how to choose applicable resources to accomplish lesson objectives. PTs should be sensitised that assessment of learners' understanding informs teaching practices. PTs should reflect on their lesson presentation in terms of the achievement of learning objectives. They should also incorporate learners' thinking and measure the impact of their teaching. Reflection should include collaborative approaches by including discussions with professional learning communities on thinking about teaching.

Lastly, PTs need to be trained on classroom management. In particular, the creation of conducive classroom environments, discipline, time management and administration may be included.

CONCLUSION

Worldwide there are requests to transform teacher education, yet many teacher training institutes fail to provide mathematics PTs with sufficient rich experiences to link theory and practice, which is essential to improve the quality of teaching and learning in mathematics at schools. To address this challenge, this study examined mathematics PTs' learning experiences at a TS.

Results indicated that some PTs could act and reflect on gestalt-driven experiences. However, an appropriate *theory*-level was not reached. At the *gestalt*-level PTs maintained, on the one hand, a Platonist belief viewing mathematics as abstract, theoretical and complex. On the other hand, an instrumental belief was upheld considering mathematics teaching and learning to be skills-driven.

At the *schema*-level most PTs shifted to an experimental belief by applying mathematics to real-life activities. They started to reflect on their teaching practices and to seek assistance from more knowledgeable others. All PTs could arrange some of their knowledge coherently and consider the impact of their teaching on learners at the *theory*-level. Nonetheless, there was some misalignment between theory and practice in terms of lesson planning and teaching methods, although PTs acknowledged a convergence of interplay between theory and practice.

This study contributes to research on TSs by providing a context to investigate the interchange between theory and practice. Within TSs mathematics PTs gain learning experiences about teaching and learning of the subject from experienced mathematics teachers. PTs' unconscious thoughts about teaching and learning of mathematics may evolve smoothly to intentional actions and reflection practices. These intentions could lead to the development of a mindful network of coherently arranged knowledge, skills and values.

PTs' development at three levels was explored. To discover the magnitude of such development, recommendations are to lengthen the project to more than one year, and to include PTs from various subject disciplines. Concrete implications for the methodology of mathematics different from the *theory*-based programmes in teacher education, as well as guidelines for a mentor-programme are also suggested.

One limitation of this paper is that only the learning experiences of mathematics PTs were taken into consideration. The experiences of the mentor-teachers could have contributed to a more holistic understanding. The study was a pilot project, which was implemented for a period of five-and-a-half months.

In conclusion, there is a need for pedagogies in teacher education which integrate PTs' experiences at a *gestalt*-level at universities with practical experiences at TSs. A focus on reflection approaches to develop a more theoretical understanding on teaching and learning of mathematics is needed. However, theory can only be constructive if PTs themselves develop the desire for a deeper understanding.

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