Teaching practice and pre-service mathematics teachers' teaching knowledge in Zimbabwe: A mixed methods study

Chipo Makamure
Belvedere Technical Teachers' College, Zimbabwe
Loyiso C. Jita
University of the Free State, South Africa

This paper examines the significance and contribution of teaching practice (TP) to the development of pre-service teachers' knowledge of teaching mathematics in Zimbabwe. Education researchers, across the globe, concur that teaching practice is an important component of "learning to teach". However, underachievement in mathematics the world over has been consistently high, and regardless of the long TP period in Zimbabwe, the failure rate in mathematics in Zimbabwe has always been dismal. This failure rate, according to research, can be linked to teacher quality. The role of TP in developing the required expertise of pre-service teachers to improve mathematics teaching therefore, remains to be established. A mixed methods approach was employed, based on an explanatory sequential design, to explore the nature and impact of teaching practice on knowledge for teaching mathematics. This study found that many mathematics teachers are a product of their experiences during teaching practice. Teaching practice may be fully effective when it is coupled with proper and adequate guidance from college and school-based mentors. Adequate monitoring of teaching practice with reference to mathematics content and pedagogy develops teaching expertise. The study recommends proper debriefing and assessment of competence after teaching practice, so that pre-service teachers who do not meet the performance requirements can be re-trained before graduation.

Introduction

> If mathematics showed signs of continuing improvement and if students were learning mathematics well, the concern about the effectiveness of teacher preparatory programs would be less urgent (Hiebert et al, 2003, p. 202).

Teaching practice (TP), which is used interchangeably with practice teaching (PT) in this study, has become a topical issue for most pre-service teacher education programs (Hamaidi et al., 2014). Much research in teacher education thus focuses on TP as a key aspect in the development of pre-service teachers (PSTs). Studies by van den Bos and Brouwer (2014) and Snyder (2012) showed that one of the types of learning designs in teacher education that has the capability to change pre-service teachers is experiential learning. This implies that mathematics pre-service teachers can develop their conceptual understanding of mathematics teaching through field experiences. Van den Bos and Brouwer (2014) concurred that learning to teach has to be considered as interaction between the conceptions and the enactment of these conceptions into teaching, which suggests that learning to teach mathematics without practicum experience can be futile. According to Livy, Vale and Herbert (2016), TP develops pre-service teachers' mathematics content knowledge. Similarly, Butterfield, Forrester, McCallum and

Chinnappan (2013) asserted that if TP is designed in a way that engages PST in activities that focus on the mathematics and areas of their mathematical difficulties, that will the development of their knowledge of mathematics. This implies that TP is not only meant to put theory into practice, it is to further develop the depth and breadth of PSTs' mathematics knowledge. Khalid (2014) contended that teaching practice is instrumental for the development of teaching quality among pre-service teachers. This is because teaching practice provides pre-service teachers with germane responsibilities, attitudes and skills that vary from their experiences as students. For example, PSTs may extend their knowledge of mathematical terms when listening to their mentor teachers during mathematics lessons, or observe teaching strategies used to promote learner understanding (Livy et al., 2016). Thus, the NCATE (2008) asserted that high quality TP (subject content and skills to teach it) makes a difference in learners' achievement in mathematics.

Other research has been conducted to study some aspects related to teaching practice. Khalid (2014) for example, found that teaching practice assists pre-service teachers to improve the skills that relate to problem identification, decision making and the selection of teaching approaches to overcome problems in classroom situations. This was found to be invaluable in developing PSTs' confidence in themselves. A study into the role of supervisors in supporting pre-service teachers to cultivate skills regarding the teaching of mathematics during TP has been conducted by Makamure & Jita (2017), who focused on supervisors' attitude, mathematics knowledge and teaching skills as quality assurance requirements for effective mathematics teaching. Precisely because of the assumed importance of TP in the education of pre-service teachers, the government of Zimbabwe has also prioritised TP in all its higher education institutions (Makamure, 2016). Accordingly, efforts to enhance teacher knowledge have culminated into the development of teacher education curriculum in Zimbabwe to reinforce what mathematics PSTs do in the classroom, through teaching practice.

To date, however, regardless of the research on pre-service teachers' mathematical knowledge development during TP, the problem of underachievement in mathematics continues unabated around the world (Ball, Hill & Bass, 2005). Learners are deficient in the required competencies to understand mathematics (Hiebert et al., 2003) and this deficiency is attributed to the level of mathematics content knowledge of teachers being alarmingly insufficient (Butterfield, et al., 2013). In addition, in spite of the long teaching practice in Zimbabwe (at least 8 months), there has been consistently disappointing mathematics results at "O" level in Zimbabwe (Kusure & Basira, 2012; ZIMSEC, 2016). This is a trend which is seen the world over (Kafata & Mbetwa, 2016). According to Suan (2014), professional development of teachers has a large impact on learner achievement. The study by Blank and de Las Alas (2009) showed that the students taught by teachers involved in faculty development scored above the students whose teachers did not participate. In addition, Hill, Rowan and Ball (2005) contended that teachers' mathematical knowledge is significantly related to student achievement. These views indicate that mathematics failure or achievement can be linked to teacher quality. Recently, some critics have questioned the significance of TP to teacher effectiveness (NCATE, 2008). Despite such research, there have been very few studies conducted as to how the experiences of PSTs during TP develop their knowledge of teaching mathematics (Khalid, 2014). This study, therefore, seeks to explore the extent to which TP could better develop mathematics teaching knowledge for prospective teachers in Zimbabwe.

Literature review and conceptual framework

> A teacher can easily become an educational leader; can create positive change in the classroom and in the lives of his/her students and can shape the environment, or even the future of the country. On the other hand, a teacher can also ruin the lives of individuals. How should these role models be educated and trained then? (Doyran, 2012, p.1).

The conceptual underpinnings of this study revolve around the notion of learning to teach, particularly, learning to teach mathematics. Lee (2003) viewed learning to teach as a process of acquiring knowledge about teaching and a devotion to acquiring formal knowledge and then applying it in the field. This implies that learning to teach is concerned about what prospective teachers should be able to do and know, to teach effectively in various contexts. In the process of learning to teach, colleges and universities provide a good deal of the theory, knowledge and skills to the pre-service teacher, the school provides the field setting where knowledge is applied and practised and the pre-service teacher marries them all (Lee, 2003). The college campus and the field experiences, thus, provide an ideal setting for "learning to teach".

The purpose of this study was to explore the role of teaching practice to PST mathematics teacher knowledge and expertise, as described by the concept of learning to teach, for secondary school mathematics in Zimbabwe. The concept of learning to teach, thus, provided this study with the opportunity to explore the PSTs' college and field experiences. Within the concept of learning to teach, the study was informed by the framework of *pedagogical content knowledge* (PCK). Shulman (1986) proposed PCK as a component which addresses the presentation of a subject using appropriate strategies of instruction and resources in a way that is understood by learners. In view of the field experiences, Grosschedl, Mahler, Kleickmann and Harms (2014) identified the concept of PCK as the amalgam of content and pedagogy. PCK therefore requires PSTs to develop an understanding of the mathematics to teach, the strategies to be used with certain kinds of students, particular topics and different learning settings (Shulman, 1986). In addition, Grosschedl et al. (2014) affirmed that PCK involves knowing how to arrange certain elements of the content so that the concepts are teachable and hence, teaching expertise may be enhanced. Researchers, such as Schmelzing et al. (2013), have the perception that PCK is developed from teaching experiences. According to Shulman (1986), PCK was introduced to be the interplay between the two constructs of theory and practice. Kahan, Cooper and Bethea (2003) and Turnuklu and Yesildere (2007) explained that the common belief among researchers and societies is that a teacher who knows mathematics content well is the best suited person to teach the subject and that students gain from him/her.

However, Hill et al. (2005) and Yusof and Zakaria (2015) contended that individuals may have well developed content knowledge of a subject, but lack the specific PCK for teaching. Shulman (1986) also advocated for the inclusion of PCK in learning to teach as it involves knowledge of content and students, as well as knowledge of content and teaching. Hence, this view of lauding content knowledge only is made without taking cognisance of the teacher's ability to present the concepts to the learners explicitly. Kahan et al. (2003) thus advised that content knowledge alone does not suffice for good teaching. With PCK, subject expertise and general pedagogy across disciplines are not treated as separate and independent but are treated as intertwined entities (Shulman, 1986). This suggests that the main concern of PCK during "learning to teach" is to find ways and means of transforming content so that it is presented to the learners in a comprehensible manner. According to Depaepe et al. (2015), Shulman's theory on teacher knowledge or learning how to teach has been influential in teacher education, especially in science and mathematics. Therefore, learning to teach largely contributes the skills component and the synthesis between knowledge and practice, thus improving the quality of education and classroom instruction. This paper, therefore, investigates the importance of practicum experiences for providing opportunities for pre-service teachers to develop mathematics knowledge for teaching.

Research questions

The study is guided by the following research questions:

1. What is the fundamental role of TP in developing PSTs' skill and confidence as mathematics educators?
2. How do PSTs perceive what they learn about mathematics, and mathematics teaching during their teaching practicum?

Method

Research paradigm and design

The pragmatist philosophy was employed to guide the selection of a mixed methods approach to realise the nature, impact and relevance of TP on mathematics teacher knowledge. The pragmatist paradigm is a philosophy which believes that education should be practical and come through experience (Fetter, Curry & Creswell, 2013). Since this study has an interest in establishing the significance and contribution of TP to mathematics knowledge for pre-service teachers, it fits well into the tenets of pragmatism. In order to achieve the purpose of the study, the mixed methods design investigated the practices, experiences and activities that shape the mathematics pre-service teachers' classroom performances during TP. The explanatory sequential design was therefore opted for, where data were collected using quantitative methods followed by a qualitative methods approach. Data collected using questionnaires were clarified and/or supported with data from the interviews to ensure the credibility and trustworthiness of the data (Terrell, 2012).

Participants

Participants in this study were pre-service teachers (PSTs) on TP. PSTs take two or three years to finish the teacher training course, depending on their entry qualifications (two years for Advanced level and three years for Ordinary level holders). Advanced level holders spend 8 months on TP whilst Ordinary level holders spend 12 months. Participants were selected from both programs. Qualified and experienced teachers in the practising schools (hereafter referred to as school-based mentors) were responsible for the daily supervision of the PSTs. In Zimbabwe, there is no additional payment above the normal salaries for the supervision of pre-service teachers by the mentors. The mentors send intermittent reports to the training colleges on the PSTs performance. In addition, workshops are normally held by the teachers' colleges to brief school-based mentors about the colleges' expectations of supervision. College lecturers also assess each student at least three times during the TP period. PSTs for both programs graduate with a diploma in mathematics education and are qualified to teach mathematics up to 'Ordinary' level. All the participants in the study could speak English as a second language.

Sampling and data collection procedures

120 pre-service teachers on TP were purposively sampled from two secondary teachers colleges, A and B (pseudonyms) in Zimbabwe. Fifty mentors were also selected to participate in the study. 105 pre-service teachers and forty-two school-based mentors answered the questionnaires about the classroom experiences of both the PSTs and their school based mentors during TP. The purpose of the mentor questionnaire was to determine mentors' views about the nature of the mathematics knowledge that PSTs acquired during their TP.

Table 1: Study sample and instruments

Instrument	Participants	Participation count	Expected sample size	Participation %
Questionnaire 1	Pre-service teachers during TP	105	120	87.5%
Questionnaire 2	Mentor teachers	42	50	84%
Focus group interviews	Pre-service teachers	22	25	88%
Focus group interviews	Mentor teachers	14	20	70%

The PST questionnaire examined their classroom experiences to determine the relevance and significance of TP to mathematics teacher knowledge. Separate follow up focus group interviews were conducted with 14 mentors and 22 pre-service teachers from the same groups that answered questionnaires. Questionnaires were administered first followed by separate focus group interviews with PSTs on TP and their school-based mentors. The focus of the instruments employed was to establish the impact and effectiveness of TP as a vehicle for gaining knowledge for teaching mathematics. The interviews focused on the

TP activities and experiences for all the participants. The table below summarises the instruments and the response rates of the participants studied.

Although the expected sample size of participants was not met in some cases, the percentages were acceptable. According to Sivo, Saunders, Chang and Jiang (2006), although a response rate of 100% should be pursued, 70% to 80% is acceptable.

Data analysis procedures

(i) *Descriptive statistics*
These include the frequencies, means, standard deviations and percentages used to analyse the quantitative data. The responses to the questionnaires were presented on a 5 point Likert scale with SA (strongly agree) taking the highest score of 5. Open-ended questions were grouped into related categories and explained. The PST and mentor questionnaires were tested for reliability using Cronbach's alpha coefficient. The coefficients were 0.850 and 0.758 respectively. According to Field (2006) a Cronbach's alpha above 0.7 indicates a strong estimation of reliability. This implies that the instruments had a relatively high internal consistency.

(ii) *Inferential statistics*: *Factor analysis*
A factor analysis was also conducted as a data reduction tool for the "experiences of teaching" theme. The purpose was to remove duplication from a set of correlated variables under the theme (Yong & Pearce, 2013). Each factor (F_i) was a linear combination of the variables (questions) under the given theme. The general formula for each factor (F_i) is given by

$$F_i = \sum_{j=1}^{n} b_{ij} x_j + e_i$$

where
b_{ij} = the coefficient or factor loading of the variables (questions) in the i^{th} row and j^{th} column.
x_j = the variables under a given theme
e_i = error term

For each factor, if the factor loading (b_{ij}) of the latent variable was at least 0.5 then it meant that the respective latent variable (questionnaire item) had a major impact on the theme.

(iii) *Interpretive analysis*
Data from interviews were grouped into related categories and explained. To meet the criteria of trustworthiness and credibility of the qualitative data, audio recordings that were transcribed into textual data were used. Pseudonyms were used in place of participants' actual names.

Results, findings and discussion

This section discusses what and how pre-service teachers reportedly learn about mathematics and mathematics teaching during teaching practice.

Pre-service teachers' mathematics content knowledge during TP

Table 2 depicts the pre-service teachers' perceptions and perspectives about their knowledge of mathematics content during TP.

Table 2: Pre-service teachers' mathematics content knowledge during TP

	Items	n	SD	D	N	A	SA	Mean	s.d.
57	The course work material covered enough content that helped me to teach well during teaching practice	104	10.6%	13.5%	7.7%	45.2%	23.1%	3.57	1.28
58	I have adequate knowledge about the mathematics content I teach	105	1.9%	6.7%	9.5%	42.9%	39.0%	4.10	0.96
59	I can think mathematically	105	0%	1.0%	18.1%	43.8%	37.1%	4.17	0.75
60	I have different ways of improving my understanding of mathematics	104	0%	1.9%	5.8%	58.7%	33.7%	4.24	0.65
61	"A" level mathematics content is enough for a teacher to teach up to "O" level	103	5.8%	11.7%	17.5%	29.1%	35.9%	3.78	1.22
63	The mathematics content in the classes that I teach is difficult	105	47.6%	34.3%	8.6%	6.7%	2.9%	1.83	1.03
64	After qualifying as a teacher, I will prefer to teach mathematics at junior level (Forms 1 and 2)	103	31.1%	30.1%	14.6%	16.5%	7.8%	2.4	1.29
65	After qualifying as a teacher, I will prefer to teach mathematics at "O" level (Forms 3 and 4)	104	4.8%	4.8%	15.4%	26%	49%	4.10	1.13
	Total average							3.52	1.04

Notes: n = Number of respondents; SD = Strongly disagree (1); D = Disagree (2); N = Neutral (3); A = Agree (4); SA = Strongly agree (5); s.d = Standard deviation.

The PSTs indicated that they were satisfied with the content that they covered in college and that the subject content knowledge they had was adequate to help them teach well during TP. This was shown by the mean scores of positive responses in relation to mathematics knowledge, which were all above 3.57 on the 5 point Likert scale. The implication of this finding is an indication of positive contribution of mathematics content knowledge to teaching performance. The low means for items 63 and 64 indicate a positive response in relation to mathematics knowledge possessed by the pre-service teachers.

However, the mentors' views about PSTs' mathematics content knowledge provide indications on the apparent discord between what they purport to know and the evidence of their content mastery and/or delivery. This was evidenced by the mentors' unwillingness to allow PSTs to teach senior classes. More so, over 80% (18/22) of the interviewed pre-service teachers preferred to teach Forms 1 and 2, which may suggest evidence of a lack of confidence about their content knowledge. 71% (10/14) mentors interviewed confirmed PSTs' low content knowledge level. For example:

> Some of them do not have content knowledge. It's like when they come they always say, from the college we were told to teach forms 1 and 2 not forms 4s and 3s. If we are to give them those form 4s and form 3s, it will be after a desperate situation, ….. otherwise they don't really want to teach form 4s because they say the college expects them to teach forms 1s and 2s. (M3)

> Pre-service teachers face problems balancing lesson plans, marking and teaching content. Most of them struggle with content, to the extent that they even go to the next lesson without being prepared… Most of them don't have time for content preparation… They have no confidence to teach 'O' level mathematics. … In addition, what they are taught in college has no link with what they teach here. … So their mathematics knowledge for teaching is compromised. (M6)

Livy et al. (2016) maintained that successful teachers need to be privy to the mathematics appropriate to the level they teach. In the same vein, Barton (2009) contended that teachers need mastery of mathematics at least 4 years ahead of the students they teach, in terms of subject content knowledge. Failure to achieve this criterion may have a negative impact on the PST's performance. In line with M3's comment above, Livy et al. (2016) contended that PST's with less content knowledge usually opt to teach lower class level mathematics, thereby avoiding an opportunity to extend the depth of their content. Livy et al. (2016) further contended that a PST's depth of mathematics can be developed when they practise teaching across different levels. This points to the fact that pre-service teachers who do not experience upper levels during their practicum experience may lack confidence to teach those levels after graduation.

The findings imply that it is critical that PSTs are acquainted with the content knowledge of the mathematics subject levels they expect to teach. If they have little to offer in the classroom, a crisis of confidence is likely to arise during TP. According to Ball, Lubienski and Mewborn (2001), teachers with more content knowledge tend to emphasise the conceptual, problem solving or inquiry aspects of their students when compared to those with less content. Similarly, Kessel (2009) affirmed that PSTs have to possess the ability and skills to solve problems if they are to be viewed as effective at teaching mathematics. Thus, Ball et al. (2001) suggested that the more content PSTs have, the more effective they can become, implying that improving content knowledge can actually positively assist PSTs in their teaching. These ideas suggest that PSTs' level of subject content knowledge is one of the strong influences upon the way they teach and also impacts on learning outcomes. Concurred by other mentors in this study, the sentiments expressed by M6 and M3 are that PSTs have been burdened by too many activities that have very little to do with the teaching of mathematics content, which should be their core business on TP. About 80% of the mentors indicated that the mathematics content learnt in colleges is not directly linked to what pre-service teachers teach during TP, as alluded to by M6 above.

One point that the mentors seemed to emphasise was the call for better articulation between the college curriculum and the school curriculum.

Pre-service teachers' knowledge about mathematics teaching

The study seeks to shed light on pre-service teachers' knowledge about teaching mathematics in relation to their classroom experiences and their teaching strategies. Table 3 presents the views of mentors about PSTs' classroom performance:

Table 3: Mentors' views (N=40)

	Item	SD	D	N	A	SA	Mean	s.d.
16	The college has done enough to prepare PSTs for teaching practice	-	5.0%	22.5%	52.5%	20.0%	3.88	0.791
17	My mentee knows the content s/he teaches	2.5%	5.0%	17.5%	52.5%	22.5%	3.88	0.911
19	Field experience courses offered in teachers' colleges for PSTs need to be enhanced in terms of peer teaching	-	2.5%	17.5%	62.5%	17.5%	3.95	0.677
20	My mentee often has problems explaining concepts explicitly to the students	2.5%	42.5%	25%	25%	5.0%	2.88	0.992

Table 3 reveals two issues, first, the impact of colleges to teacher knowledge, and second, the link between mathematics content knowledge and knowledge for teaching mathematics. The study establishes there is a perception that training institutions are instrumental in preparing PSTs for classroom practices. This is indicated by the mentors' responses to items 16 and 19 (72.5% and 80% agreed respectively), compared to 5% and 2.5% who disagreed. In addition, the responses for items 17 and 19 suggest that although PSTs have the mathematics content (item 17), they may still be lagging behind in terms of pedagogy (item 19). With regard to item 20, there were mixed views concerning PSTs' ability to explicitly explain concepts to pupils. This could explain that while mathematics content knowledge is one thing, mathematics teaching knowledge is quite another.

These ideas are supported by the interviews with PSTs which suggested that while they need content knowledge to teach mathematics, the mathematics content only does not enable them to make information accessible to the learners. 86.4% (19/22) of the pre-service teachers agreed in the interviews that they knew their mathematics content but professed difficulties in teaching it. Thus, Ball et al. (2001) asserted that it is fundamental that pre-service teachers are conversant with the content knowledge of the mathematics they teach in a way that they are able to deliver it to the learners. Similarly, van Es and Conroy (2009) assented that teaching mathematics for understanding involves proficiency with and knowledge of mathematical concepts and procedures and the ability to make sense of the mathematics they teach. The PSTs' sentiments during interviews about teaching mathematics also echo the opinion of Turnuklu and Yesildere (2007) who asserted that teachers have to be very conscious about students' ways of thinking when teaching mathematics. Turnuklu and Yesildere contended that if teachers fail to translate abstract concepts into a form that is teachable and enables students to relate the mathematics they learn to what they already know, then learning with understanding is not achieved. This suggests that mathematics should be applicable to the learners' real life situations. Hine (2015) therefore recommended that mathematics teachers need to be able to calculate problems and know how to present and communicate the concepts to the learners for understanding.

The data collected indicated that most of the PSTs used mainly the demonstration method in the classroom, although other teaching methods were occasionally mentioned. One of the challenges in the application of these teaching methods was the use of vernacular language to explain mathematical concepts. One PST, A4 said:

> For me I know they say you have to teach in English when teaching mathematics, but then, looking at the school that I am and the classes that I have, I cannot always use English, because most of my pupils especially form 2, the majority of them have 20 to 36 units at grade 7. If I use English, they will tell you, madam, "we have not understood anything". So I usually use English and Shona. I usually demonstrate. If they understand my demonstration, I also ask them to demonstrate. (A4)

A4 suggested that the problems of language can obstruct the conceptual understanding of topics taught in the classroom and this is liable to hinder the learners' mathematical proficiency. This idea resonates with those of Essien (2018) who argued that teachers are normally faced with the challenge of striking the balance between attention to English language, and attention to mathematics concepts and mathematical language among learners not yet proficient in English. Mother language may therefore be used to improve comprehension. Whilst the PST's intentions were noble, this may not work in the interest of learners. Rakicioglu-Soylemez and Eroz-Tuga (2014) found that some pre-service teachers used Turkish as a medium of instruction but then gave learners work to do in English. Learners had challenges in linking the questions to what was taught in a different language. Whilst language barriers can be a problem, some scholars, like Essien (2018) recommend that instruction in mathematics should focus on enhancing mathematical reasoning and understanding and not accuracy in using a language (whether it is first or second). This implies that PSTs should not be side-tracked by mathematical ideas expressed in imperfect language. Instead, they should first focus on promoting mathematical meaning. In the same vein, mathematics, like any other language, is a specialised language with its own didactics. This suggests that attempting to interpret and transcribe mathematical concepts in a mother language is likely to distort the real meaning of the ideas being taught/learnt.

In response to how they experienced the job of teaching, PSTs raised concerns about too much paper work, which included lesson plans, schemes of work, and evaluation of lesson plans, among others. A3 expressed her feelings as follows;

> Yes, for me, it's the work load. The load is too much. You need to write those DLPs [daily lesson plans], you need to evaluate them. You need to mark every exercise. You need to give an exercise every day in mathematics. It's so challenging that you mark 200

> books in a day. In fact, more time is spent on paper work than teaching. At the end of the course, we will be specialists in writing lesson plans than teaching. Our job is to teach mathematics. (A3)

A3 is lamenting about the tasks enforced by training teachers' colleges whilst on TP. A3 complained that PSTs do more clerical work in schools than actual classroom teaching. The clamour is directed towards 'more time to teach mathematics' and less paper work. This implies that there is a perception among PSTs that if the college curriculum is revised to focus more on the delivery of the actual mathematics content to the learners during TP, then PSTs' mathematics knowledge for teaching may be enhanced.

Pre-service teachers' classroom experiences

Factor analysis: Classroom experiences

The quantitative results, through factor analysis, by and large, suggest that PSTs were satisfied with their classroom experiences during TP. Factor analysis was conducted for the 24 items of the theme "experiences of teaching". Experiences of teaching in the questionnaire were re-categorised to produce nine factors as follows: F1-motivational strategies (4 items), F2-training college support (2 items), F3-classroom management (3 items), F4-teaching strategies (3 items), F5-pedagogical competence (2 items), F6-knowledge about learners (2 items), F7-impact of TP on teaching mathematics (3 items), F8-practising schools support (2 items) and F9-teaching resources (1 item). Each factor (F_i) was a linear combination of the latent variables (question items) under the given theme (see Appendix B). These factors explained 69.8% of the total variability under this theme (see Appendix A).

The averages of the latent variables were used to calculate the satisfaction index as follows:

Satisfaction Index is $\frac{\text{Av} - |\text{a}|}{|A| - |a|} = \frac{0.5802-0.0210}{0.8592-0.0210}$ = 66.7% (see Appendix B)

The 66.7% can be interpreted as pre-service teachers' positive classroom practices, which is in line with the quantitative results of the "experiences of teaching", with a mean response of 3.973 on the Likert scale as shown in Table 4.

Table 4: Pre-service teachers' classroom experiences

	Item	n	SD	D	N	A	SA	Mean	s.d.
7	The college has done well to prepare me for the classroom	105	-	8.6%	8.6%	41.0%	41.9%	4.16	0.911
8	I am confident to teach mathematics	105	-	-	3.8%	23.8%	72.4%	4.69	0.543
9	My classroom management skills are quite appropriate	105	-	2.9%	12.4%	57.1%	27.6%	4.1	0.714
10	I have an understanding of how students learn mathematics	100	-	3.0%	22%	50.0%	25%	3.97	0.771

	Item	n	SD	D	N	A	SA	Mean	s.d.
11	I can apply different teaching approaches during lessons at the appropriate time	103	-	3.9%	8.7%	49.5%	37.9%	4.21	0.762
12	Using a variety of approaches to teach a mathematical concept may confuse students	105	22.9%	35.2%	12.4%	14.3%	15.2%	2.64	1.381
13	Knowing about different approaches means I can use them for teaching	101	6.9%	10.9%	7.9%	45.5%	28.7%	3.78	1.18
14	I use the textbook quite often during my lessons	104	2.9%	10.6%	23.1%	35.6%	27.9%	3.75	1.068
15	I can select appropriate teaching resources that enhance my teaching approaches for a mathematics lesson	104	-	-	9.6%	52.9%	37.5%	4.28	0.63
16	Teaching practice has given me an opportunity to experiment with teaching approaches covered theoretically at college	105	1.0%	1.9%	1.0%	36.2%	60.0	4.52	0.708
17	I got a lot of insight on how students learn mathematics during teaching practice	105	-	1.0%	6.7%	44.8%	47.6%	4.39	0.658
18	It is quite easy to utilise the skills and techniques gained in college during teaching practice	103	1.9%	14.6%	22.3%	41.7%	19.4%	3.62	1.021
19	I can motivate students who lack the desire to do mathematics	105	1.0%	2.9%	6.7%	50.5%	39.0%	4.24	0.779
20	There is a sound relationship between myself and my students	105	-	3.8%	8.6%	41.0%	46.7%	4.3	0.786
21	I am concerned about my ability to meet the needs of slow learners	103	1.9%	3.9%	13.6%	42.7%	37.9%	4.11	0.917
22	I can adjust my styles of teaching to suit various learners	102	-	1.0%	12.7%	40.2%	46.1%	4.31	0.731
23	I give remedial work every time students have difficulties in grasping a concept	104	-	11.5%	20.2%	34.6%	33.7%	3.9	1
24	I respect and accept students' thoughts and suggestions	105	-	-	9.5%	40.0%	50.5%	4.41	0.661
25	I allow students to use their own methods of learning	105	2.9%	12.4%	21.0%	46.7%	17.1%	3.63	1.002
26	I can assess and evaluate my students' performance in the classroom	105	1.9%	1.0%	4.8%	45.7%	46.7%	4.34	0.782
27	The school is doing enough to assist me during teaching practice	104	8.7%	10.6%	17.3%	29.8%	33.7%	3.69	1.278
28	The college is doing enough to assist me during teaching practice	104	3.8%	6.7%	16.3%	40.4%	32.7%	3.91	1.053

	Item	n	SD	D	N	A	SA	Mean	s.d.
29	Teaching is what I expected in life	103	13.6%	10.7%	17.5%	31.1%	27.2%	3.48	1.356
30	My expectations before teaching practice match my experiences during teaching practice	104	13.5%	25.0%	24%	31.7%	5.8%	2.91	1.158
	Classroom experiences							3.973	0.910

However, PSTs' satisfaction may not necessarily mean effectiveness in teaching mathematics. Nevertheless, satisfaction is likely to enhance self-confidence and feelings of self-confidence, according to Sadler (2013), which were found to be related to content knowledge and teaching skills. For instance, a teacher with confidence has no fear of taking risks to apply new teaching strategies (Sadler, 2013).

Pre-service teachers' views about TP Supervision

This section focuses on how mathematics teaching knowledge is shared with PSTs by their school-based mentors. Table 5 exhibits pre-service teachers' experiences with their school-based mentors obtained from a questionnaire.

Table 5: Pre-service teachers' experiences with mentors

	Item	n	Mean	s. d.
31	A mentor is an expert in teaching mathematics	104	3.29	1.297
32	Mentors are always motivated and enthusiastic about teaching mathematics	104	2.96	1.222
33	My mentor helps me to plan for the lessons	104	2.64	1.307
34	My mentor helps me to decide on the media to use for developing concepts	103	2.47	1.178
35	My mentor helps me to decide on which teaching approaches to use for my lessons	104	2.71	1.220
36	My mentor let me sit in a lesson he/she was teaching during my TP	104	2.74	1.400
37	My mentor demonstrated some of the teaching approaches before asking me to teach a lesson	104	2.45	1.238
38	My mentor coached me on how to teach	103	2.90	1.287
39	My mentor regularly sits in on lessons that I teach	101	3.07	1.283
40	My mentor allows me to use the teaching methods I feel will be useful	104	4.03	1.038
41	My school-based mentors provide constructive feedback and professional support	104	3.49	1.254
43	My school-based mathematics mentors appropriately model blending content and teaching strategies	104	3.19	1.006
	Total average		3.00	1.227

Table 5 illustrates that PSTs were less positive about the assistance they received from their mentors as shown by the several mean item scores below 3.0. The highest mean on this theme was 4.03 given by the statement "My mentor allows me to use the teaching methods I feel will be useful". Such a response could be expected because, some PSTs were normally on their own in the classrooms during teaching practice. Some mentors tended to place the burden of teaching on the PSTs without adequate assistance and hence, the PSTs were likely to employ the approaches they wanted. This assertion was confirmed in the interviews with PSTs in which they affirmed that supervision was limited and for some was completely absent. This is what student R3 articulated:

> I am not getting enough assistance from the mentor and I'm being told to attend to HOD classes when they are having a meeting. I had to ask for help from other maths teachers in the department. (R3)

A2 had the view that the supervision was doing more harm than good to her. She expressed her views as follows:

> The fact that a mentor comes to assess me and then corrects me in front of the pupils, eish!. The fact is, I don't have anyone to supervise me. If I had a mentor, she would teach me every day before I go for a lesson and I wouldn't make errors in front of the pupils. As you will be trying to work out a problem on the board, the supervisor raises her hand and corrects you then and there. It actually exposes me to the pupils, and I learn nothing from the mentor. (A2)

PSTs' complaints point to the fact that mentors had not been cognisant of their responsibilities. In view of these complaints by PSTs, Gulamhussein (2013) argued that the they need support, encouragement, reassurance, comfort and guidance from the mentors to boost their teaching performance.

During interviews, some PSTs also expressed their views with regards to the challenges faced when teaching mathematics during TP. P2 stated:

> Sometimes you discover you are now covering a topic, maybe sketching graphs then you discover that these pupils don't know anything. What do I do? That's why I have to re-teach. So I said let me just cancel this one, and do substitution first because the students could not draw the table of values. ... If the mentor was available, I wouldn't have such problems. (P2)

The sentiments by P2 suggested improper planning, which could have been aggravated by inadequate guidance from the mentors. In the same vein, T1 also faced the challenge of teaching through trial and error. Here is what he said,

> Preparing media to capture the interest of the pupils has been challenging to me. I had problems choosing media to teach certain topics and media to teach certain groups of students. (T1)

The excerpts above portray the perception that the PSTs could have done better to make mathematics meaningful with better supervision from the mentors. This implies that TP can be effectively executed and mathematics knowledge for teaching enhanced if pre-service teachers receive proper guidance from the school-based mentors.

Discussion

Views and experiences of teaching mathematics during TP

Regardless of the level of mathematics content knowledge that PSTs have, questionnaires and interview results in this paper demonstrate they have challenges with their teaching pedagogy, that is, teaching styles/methodologies, to mention a few. Several research studies (Kyriacou & Stephens, 1999) have therefore advised that more attention be paid to these challenges and concerns of field practices during learning to teach. Jusoh (2013) asserted that a failure to address the concerns of TP, such as methods for teaching mathematics, knowledge of the subject matter, supervision processes, coping with work load, and disillusionment of PSTs, may aggravate problems for the already sophisticated teacher training programs.

The findings of the study seem to suggest that the effectiveness of mathematics teaching does not depend only on mathematics content knowledge. It depends also on the way the subject is presented to the learners. The study established that while some PSTs had good mathematics content knowledge, they lacked the skills to present the subject to the learners comprehensibly. Makamure (2018), thus, encouraged more personalised and process-oriented approaches to teaching, to empower learners. Hence, training colleges and TP schools have a role to play to improve the pedagogy of teaching mathematics. This view resonates with the finding by Hine (2015) that pre-service teachers require additional training in mathematical pedagogy. Pre-service teachers therefore need to be well guided in both mathematics content and pedagogy by their mentors (school and college based) in order for them to have the ability to solve problems and to present solutions to the students understandably and with confidence, if TP goals are to be met.

Conclusion

The purpose of this study was to investigate the significance and contribution of TP to mathematics teacher knowledge as it is described by the concept of learning to teach. The study demonstrates and concludes that while TP is an important component of teacher education, its contribution to the development of mathematics knowledge and expertise can be futile if the pre-service teachers' experiences and practices before and during teaching practice are substandard. Hence, Hurrell (2013) and Grosschedl et al. (2014) asserted that teaching practice needs to be coupled with a reflection on classroom experiences, and the enactment of identified changes, in order to progress towards teaching expertise. Thus, the fact that Zimbabwean mathematics pre-service teachers spend at least 8 months on teaching practice may therefore not be evidence enough to conclude that they are quality mathematics teachers.

Recommendations

In order for TP to be more fruitful to the development of knowledge of teaching mathematics among PSTs:

- there is need for proper debriefing and assessment of competences after TP so that pre-service teachers who do not meet the performance requirements can be recommended for re-training before graduation.
- technological issues in the development of knowledge for teaching mathematics should be considered. For example, PSTs can have online discussion groups for communicating with and assisting one another during the TP year.

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Appendix A: Experiences of teaching: Factor analysis - total variance explained

Comp-onent	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumu-lative %	Total	% of variance	Cumu-lative %	Total	% of variance	Cumu-lative %
1	4.929	20.536	20.536	4.929	20.536	20.536	2.477	10.322	10.322
2	2.031	8.461	28.997	2.031	8.461	28.997	2.024	8.433	18.755
3	1.840	7.668	36.665	1.840	7.668	36.665	1.973	8.219	26.975
4	1.676	6.982	43.647	1.676	6.982	43.647	1.957	8.154	35.128
5	1.521	6.336	49.983	1.521	6.336	49.983	1.945	8.104	43.233
6	1.393	5.806	55.789	1.393	5.806	55.789	1.828	7.616	50.848
7	1.320	5.498	61.287	1.320	5.498	61.287	1.806	7.527	58.375
8	1.028	4.284	65.571	1.028	4.284	65.571	1.386	5.776	64.151
9	1.011	4.214	69.785	1.011	4.214	69.785	1.352	5.634	69.785
10	.924	3.849	73.633						
11	.861	3.589	77.222						
12	.756	3.151	80.373						
13	.689	2.871	83.244						
14	.580	2.417	85.661						
15	.566	2.359	88.019						
16	.533	2.220	90.239						
17	.428	1.783	92.022						
18	.391	1.629	93.651						
19	.341	1.421	95.072						
20	.303	1.261	96.333						
21	.278	1.159	97.492						
22	.222	.925	98.417						
23	.206	.858	99.275						
24	.174	.725	100.00						
Extraction method: Principal component analysis.									

A factor analysis was conducted as a data reduction tool on "experiences of teaching". The 24 items on experiences of teaching were re-categorised to produce nine factors. These factors are F1-motivational strategies (4 items), F2-training college support (2 items), F3-classroom management (3 items), F4-teaching strategies (3 items), F5-pedagogical competence (2 items), F6-knowledge about learners (2 items), F7-impact of TP on teaching mathematics (3 items), F8-practising schools support (2 items) and F9-teaching resources (1 item). The factors explained 69.785% of the total variability under this theme (see table above). The purpose was to remove duplication from a set of correlated variables under various themes (Yong & Pearce, 2013).

Each factor (F_i) was a linear combination of the latent variables (question items) under a given theme. The general formula for each factor (F_i) is given by $F_i = \sum_{j=1}^{n} b_{ij}\, x_j + e_i$ where

b_{ij} = the coefficient or factor loading of the variables (questions) in the i^{th} row and j^{th} column.
x_i = the latent variables under a given theme
e_i = error term

For example: Factor 1 $F1 = b_{11} x_1 + b_{12} x_2 + b_{13} x_3 + \ldots\ldots\ldots + b_{1n} x_n + e_1$

$F2 = b_{21} x_1 + b_{22} x_2 + b_{23} x_3 + \ldots\ldots\ldots + b_{2n} x_n + e_2$

$Fm = b_{m1} x_1 + b_{m2} x_2 + b_{m3} x_3 + \ldots\ldots\ldots + b_{mn} x_n + e_m$

For each factor, if the factor loading (b_{ij}) of the latent variable was at least 0.5 then it meant that the respective latent variable had a major impact on the theme.

An index (I_n) showing participants' satisfaction about teaching practice under different themes was also calculated using the "averages" of the latent coefficients. The formula below was used to calculate the satisfaction index (I_n).

$$I_n = \frac{Av - |a|}{|A| - |a|}$$

where A_v = grand average (average of the averages of the latent coefficients for each factor).
$|a|$ = the modulus of the smallest average of the latent coefficients in each column.
$|A|$ = the modulus of the largest average of the latent coefficients in each column.

The Appendix A table shows the factor loadings of the latent variables (question items on the theme under consideration).

Appendix B: Factor analysis: Classroom practices - rotated component matrix

	Component								
	1	2	3	4	5	6	7	8	9
The college has prepared me for the classroom	-0.161	0.726	0.016	0.175	0.163	0.055	0.248	0.148	0.012
I am confident to teach mathematics	0.089	0.048	0.284	0.037	0.153	0.106	0.609	0.153	-0.180
My classroom management skills are quite appropriate	0.106	0.018	0.686	0.206	0.347	-0.003	0.243	0.101	-0.118
I have an understanding of how students learn mathematics	0.169	-0.112	0.646	0.016	0.138	0.232	0.107	0.065	0.316
I can apply different teaching approaches during lessons at appropriate times	0.043	0.023	0.141	0.718	0.122	0.146	0.162	-0.092	-0.222

	Component								
	1	2	3	4	5	6	7	8	9
Using a variety of approa-ches may confuse students	-0.317	0.100	0.231	0.067	0.130	-0.270	-0.651	0.112	0.038
Know about different approaches means I can use them for teaching	0.245	0.407	-0.178	0.089	-0.004	0.385	-0.028	0.467	-0.055
I use the text book quite often during my lessons	0.072	0.106	0.091	0.053	0.116	0.081	-0.019	0.067	0.859
I can select appropriate teaching resources that enhance my teaching	0.700	-0.027	0.219	0.020	-0.142	-0.019	0.134	-0.017	-0.028
Teaching practice has given me opportunity to experiment approaches done at college	0.375	0.369	0.380	-0.196	0.144	-0.074	-0.216	0.357	-0.256
I got a lot of insight on how students learn mathematics during TP	0.287	0.042	0.282	0.093	0.280	-0.094	0.082	0.657	0.147
It is quite easy to utilise skills gained in college during TP	0.105	0.320	0.005	0.130	0.690	-0.009	0.042	0.214	0.111
I can motivate students who lack the desire to do mathematics	0.634	0.002	-0.023	0.332	0.299	0.260	0.116	0.061	-0.070
There is a sound relationship between myself and students	0.593	-0.143	0.004	0.014	0.289	0.083	0.272	0.060	0.067
I am concerned about my ability to meet the needs of slow learners	0.618	0.106	0.026	0.188	0.026	0.185	-0.238	0.124	0.240
I will be able to adjust my styles of teaching to suit various learners	0.352	-0.046	0.166	0.715	-0.178	-0.022	-0.028	0.184	0.112
I give remedial work every time students have difficulties	0.021	0.155	0.033	0.729	0.211	0.037	-0.047	-0.010	0.217
I respect and accept students thoughts and suggestions	0.189	-0.010	0.104	0.126	0.168	0.788	0.1459	-0.069	-0.122
I allow students to use their own methods of learning	0.034	0.142	0.183	0.027	0.068	0.798	-0.050	0.008	0.337
I can assess and evaluate my students' performance in the classroom	0.008	0.257	0.698	0.235	-0.321	0.145	-0.008	-0.030	0.071
The school is doing enough to assist me during TP	0.458	0.303	0.030	0.099	0.288	0.083	0.035	-0.613	-0.062

	Component								
	1	2	3	4	5	6	7	8	9
The college is doing enough to assist me during TP	0.040	0.878	0.097	-0.022	0.018	0.049	-0.042	-0.152	0.128
Teaching is what I expected in life	-0.046	0.213	0.183	0.112	0.200	-0.161	0.763	-0.049	0.166
My expectations before TP match my experience after TP	0.061	-0.027	0.120	0.074	0.779	0.270	0.152	-0.117	0.076
Averages	0.636	0.802	0.676	0.721	0.735	0.793	-0.021	0.022	0.859
Grand average									0.580
* Extraction method: Principal component analysis. * Rotation method: Varimax with Kaiser normalisation.									
*a. Rotation converged in 11 iterations.									

Satisfaction Index is $\frac{Av - |a|}{|A| - |a|} = \frac{0.5802-0.0210}{0.8592-0.0210} = 66.7\%$

Dr Chipo Makamure is a Mathematics lecturer in the Department of Natural Sciences at Belvedere Technical Teachers' College, Number 1 Harvard Road, Belvedere, Harare, Zimbabwe. She holds a PhD in Curriculum Studies from the University of the Free State, South Africa. Her research interests include teacher education development in mathematics.
Email: makamburec@gmail.com

Professor Loyiso Jita is the Dean of the Faculty of Education, University of the Free State, South Africa. His research interests lie in classroom reform and instructional leadership in science and mathematics education.
Email: jitalc@ufs.ac.za

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