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Structures, Resources and Tools to Facilitate Mathematics Teaching during Teaching Practice

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Abstract This study explores the structures, resources and tools that pre-service teachers on teaching practice are subjected to in order to facilitate learning to teach mathematics. The main issue at hand pertains to the perennial challenges that PSTs encounter when attempting to bridge the gap between theoretical knowledge acquired in institutions of higher learning and its practical implementation within the classroom setting. The variation between theoretical expectations of teaching and actual practices in the classroom has been a relational lacuna in academic research worldwide. This dissonance between theory and practice in the field could hamper the PSTs' opportunities for academic success during TP. It is therefore necessary to address comprehensively the issue of the resources, tools and structures that can assist in marrying theory and practice in order to enhance mathematics proficiency of PSTs during TP. This was a mixed methods study based on an exploratory sequential design. University supervisors, school-based mathematics mentors and mathematics pre-service teachers participated in the study. All the groups responded to the interview questions whilst PSTs and school-based mentors answered questionnaires over and above the interviews. This study found that PSTs' knowledge for teaching mathematics was stifled by several factors that included improper and insufficient training to equip university and school-based mentors with the necessary mentoring skills. The PSTs hence were mostly left manning the classrooms on their own as relief teachers. However, while PSTs probably needed exemplary models from their mentors throughout the TP period, they sometimes needed to be independent thinkers. The study also found out that a lack of the tools such as ICT and technology augmented the challenges faced by PSTs when teaching mathematics during TP.

Keywords Mathematics Teaching, Mentors, Pre-service Teachers, Teacher Preparation, Teaching Practice

1. Introduction

It is difficult to train PSTs without practice [1]. This is because PSTs need exposure to various teaching experiences for them to be fully acquainted with the teaching knowledge. Teaching practice has been considered to be part of learning to teach for pre-service teachers and the goal of learning to teach is to improve classroom instruction as well as the quality of education [2]. According to De Neve et al. [2], the process of learning to teach is influenced by the schools in which pre-service teachers (PSTs) practise. This implies that the PSTs' experiences in schools, on-the-job interactions and the identification of supportive antecedents can affect the PSTs' pre-existing knowledge during training [2]. Despite being exposed to theoretical lessons about teaching practice prior to getting into the field, the implementation of theory can be a tall task as PSTs experience unpredictable challenges in the classroom. To facilitate learning to teach during TP, school-based mentors are normally assigned to guide PSTs in order to shape their teaching styles since they spend much time with the school instructors. According to Farrell [3], Kelly and Tannehill [4], the mentor, to this end, suggests, informs and makes recommendations with regard to teaching. Problems faced by PSTs on teaching practice are not given but normally constructed [5]. This is when the

mentors' practices conflict with their prescribed roles as mentors [6]. For example, Maphosa et al. [7] established that some school-based mentors treat PSTs as relief teachers, which could affect PSTs' performance, hence, impeding their process of learning to teach. Literature has also revealed that a lack of resources and other tools for use in the field has stifled the PSTs' process of learning to teach. These resources include job resources such as PST autonomy and collegial support [2], personal resources which include PSTs' continuing professional development and self-efficacy [8], as well as other tools such as innovative curriculum materials which include exposure to the internet and technology to facilitate teaching. This study therefore investigates the main structures, tools and resources that can foster effective mathematics teaching of pre-service teachers in Zimbabwe as part of learning to teach during pedagogical internship.

Statement of the Problem

The main issue in this study relates to the incessant challenges that PSTs experience when attempting to cover the gap between theoretical knowledge acquired in institutions of higher learning and its practical implementation within the classroom setting. This fallout between theoretical knowledge of PSTs and their practices in the field suppresses the PSTs' opportunities for academic success during TP. Considering TP as a vital tool in the field of teacher education, which increasingly underscores the significance of aligning theory and practice, it therefore becomes imperative to address comprehensively the issue of the resources, tools and structures that can enhance mathematics proficiency during TP. This study therefore seeks to answer the research question: How do PSTs reportedly learn about mathematics and mathematics teaching during TP, that is, what structures, resources and tools do PSTs employ to facilitate learning to teach Mathematics in the field?

Teaching Practice Structures

Teaching practice structures in the context of this study include PSTs' experiences with their school-based mentors during TP. The role of school-based mentors according to Kelly and Tannehill [4], is to provide guidance and to foster skills that enable PSTs to succeed as teachers. Mentoring also affords PSTs the ability to confront cumbersome situations in the classroom and develop an understanding of the manner in which learners learn [9]. Mentors do not only demonstrate skills as tools for "learning to teach and assist to understand the teaching of mathematics but can also render emotional support for the PSTs [4]. However, Feiman-Nemser [5] contends that PSTs should be innovative during TP rather than just observing and copying the mentor. Nevertheless, if the entire process of teaching and mentoring is not properly monitored, the PSTs' innovativeness can be barred when they conform to what the mentors dictate to them. This implies that the PSTs should work together with the mentor collaboratively in order to nap the problems of teaching practice in the bud.

The issue of training mentors has been topical in the teaching practice fraternity. According to Hollins et al. [10], some school-based mentors are appointed on traditional standards of classroom experience only, without mentorship training. In Zimbabwe, the mentors appear to be oblivious of their role in mentoring PSTs attached to them. This is an indication that mentors, both experienced and qualified teachers in schools require thorough workshopping to instill in them supervisory skills that can assist PSTs to grow professionally [7]. Hollins et al. [10] also assert that there is an assumption that a good mathematics teacher will be good at guiding PSTs during TP. An improper consideration and assignment of mentors may therefore downplay the significance and efficiency of pedagogical internship [4]. According to Hollins et al. [10], teacher preparation influences teaching competence, and teaching competence affects the quality of learning opportunities for learners. The quality of learning opportunities for learners determines learning outcomes. This implies that significant improvement in PST preparation may prompt academic performance for learners. Trainings, workshops or meetings for both university and school-based mentors are therefore quite rudimentary for effective teaching practice [11]. Hollins et al. [10] described five categories of mentors as part of the structures to be taken note of during TP, since these structures can affect PSTs' performance on TP. A mentor develops from the pre-disposition stage, through the disequilibrium, and transition stages to confidence and efficacy stages where the mentor begins to have feelings of pride and confidence in their achievements. This means that at every stage of mentor development, training is necessary.

Resources

De Neve et al. [2] described the resources that can prompt the PSTs' effective learning of mathematics and mathematics teaching. Two types of resources were identified, viz; job and personal resources. The job resources include PSTs' teacher autonomy and collegial support as contexts for teacher learning [12]. According to Varatharaj [13], teacher autonomy is considered as the PSTs' freedom to determine their own teaching strategies and methods of assessment. The teacher autonomy as a job resource also entitles PST to free determination of learners' goals. This way, PSTs may develop into innovative and creative "teaching learners". In addition, by given the prerogative to control their classroom activities, PSTs may develop the feeling of owning their learning process and practice, and are likely to choose their own learning path, thus enhancing their desire to change and maintain the change in teaching [2]. Being too prescriptive and bureaucratic to the PSTs hence, may impede their

development as student teachers.

The intellectual growth of PST can also be enhanced by collegial support as a special job tool / resource for PSTs. In this regard, schools can therefore be referred to as professional learning communities (PLCs), which prompt deprivatised practice, reflective dialogue, and collective responsibility among PSTs [2]. Deprivatised practice involves PSTs advising and coaching each other, sharing ideas and giving feedback for better classroom practices. Reflective dialogue is when PSTs reflect on their own classroom practices and discuss them with colleagues. In the same vein, collective responsibility involves discussing teaching methods for particular topics in order to develop their professional identity [14]. In addition to job resources, PSTs in the field also require personal resources. Self-efficacy is an example of a personal resource that reflects the confidence in learners when performing certain tasks. Self-efficacy as a personal resource develops PSTs professionally because the innate desire in them compels and affects choices of activities to assist the learners [15]. Continuing Professional Development has also been considered as an essential and viable personal tool for PSTs in the field, [8] which may be designed to foster learning to teach mathematics. Carpenter et al. [16] identified the Cognitively Guided Instruction (CGI) where teachers take part in the development of learners' mathematical thinking. Hence CGI can be utilised as a resource that guides the teaching and learning of mathematics because it encourages PSTs to be learners rather than teachers as they spend time listening to the learners presenting their thinking. CGI thus, becomes a tool that inhibits teacher dominance in the classroom. The Purdue Study by Wood and Sellers [17] established the Problem-centred mathematical instruction as another tool that PSTs can use to improve their performance. This approach is based on constructivism, implying that learners learn mathematics effectively when they construct mathematical meaning on their own. This is an effective way of communicating mathematical knowledge to improve their teaching expertise**. "**Teaching to the Big Ideas" (TBI), is a study conducted by Randall and Carmel [18] for teachers to develop their knowledge of mathematics. The study was also meant to establish how teachers' mathematics content knowledge affects their teaching. PSTs' involvement in such studies may improve their expertise.

Harrison [19] condemned the tendency of sticking to the textbook verbatim which they said obstructed effective "learning to teach". Harrison [19] hence advocates for the use of innovative curriculum materials by PSTs which address learners in the 21st century. Harrison's [19] idea means that whilst the textbook is an essential tool for learning to teach, PSTs do not have to depend on it solely as a teaching resource.

2. Materials and Methods

This study is part of the long study carried out to explore the mathematics PSTs' year-long field experiences during learning to teach mathematics. This is a mixed methods study based on the exploratory sequential design. The design was deemed appropriate for this study because, after collecting data using the qualitative approach, quantitative means could be used to clarify, adjust and replenish the results to ensure the validity and trustworthiness of the findings (Terrell, 2012). So, first, semi-structured interviews were employed to seven (7) university-based supervisors to establish how the universities prepared the PSTs for TP before going into the field, how universities prepared school-based mentors for TP supervision as well as university supervisors' preparation for TP supervision. The interviews were also used to ascertain the structures and teaching resources availed to PSTs to facilitate their practice. This was meant to delve into the strategies used by universities to improve PSTs' professional growth. Secondly, fourteen (14) mathematics school-based mentors also answered oral interviews before 42 of them completed questionnaires to find out how PSTs could be assisted academically, socially and educationally (job resources) in order to produce a fully-baked mathematics teacher. By and large, the instruments were meant to shed light on the factors affecting mathematics PSTs' performance during TP. Lastly, interviews and questionnaires were also administered to 22 and 120 PSTs respectively, to unravel and confirm the teaching resources at their disposal in order to facilitate TP. In this study, an exploratory sequential design was applied, where the interviews were mainly used to collect data whilst the questionnaires were used to confirm the responses given during interviews. The questionnaires were monitored closely to avoid discussion of answers by the participants in order to ensure the validity of the results. This enabled the interpretation of results to be consistent and objective. Interviews were recorded to enhance the reliability of the data collected and member checks were used time and again during interviews to ensure the validity of data.

3. Results and Discussion

The findings of this study appertain to the preparation of PSTs, assessment and training of school-based mentors, training of university supervisors and the employment of support resources during TP, as attributes constituting the means, tools and structures through which knowledge is shared with PSTs to hoist up their mathematics teaching skills.

Staff Development Strategies as Tools to Facilitate Learning Mathematics

Pre-service Teachers' Preparation for TP

The interviews conducted with the university lecturers indicated that student teachers enrolled were taught and were knowledgeable about the mathematics content that they were expected to teach and hence should have the basic knowledge required to provide instruction that fosters mathematical understanding. College lecturers confirmed that they conduct workshops prior to TP, providing opportunities for peer teaching and allowing them to use ICT equipment as forms of pedagogical support to facilitate TP. However, some lecturers indicated the absence of university workshops prior to TP but confirmed subject-specific pedagogical support which was too short to assure the PSTs' ability to deliver a lesson. The following lecturers' remarks about prior TP preparations were captured as follows:

Lecturer 3: To improve lesson delivery among PSTs, the college has done something in our departments there. We do workshops at the college level, but not particularly for mathematics students.

Lecturer 2: We can say that the college is doing not much regarding pre-TP preparation because, for pedagogy, besides the mathematics section, we have sections known as professional studies where they also learn how to teach. There is more of theory, theory, theory and little on the practice. Yes, we sometimes do peer teaching with them but I think less time is being allotted and limited resources are being channelled to that area. Yes, we do conduct pre-service workshops before they go on TP.

The remarks above show that the student teachers are exposed to the use of ICT equipment prior to TP, though it's limited. Group workshops are conducted but not specifically for mathematics PSTs. They also reported that limited time and depleted resources are channelled towards pre-TP staff development. Group workshops may not be very beneficial to mathematics PSTs because mathematics has its own didactics different from other subjects and PSTs may gain from special attention. Workshops conducted as a mixed group may be limited in addressing the structure and logic of teaching mathematics, Makamure [20]. Group workshops which do not separate subject-specific needs could be a cause for concern because teacher education institutions play a significant role in preparing a highly qualified workforce [21]. Mathematics PSTs therefore need the college support that is specifically meant to equip them with the mathematics content and pedagogical skills to teach it during TP. Hine [22] avers that pedagogical support is for the improvement of PSTs' learning. The remarks show that the pedagogy is more of theory than of practice and not every PST is involved in peer teaching because of limited time. To this end, Leke-ateh et al. [23] recommend that PSTs should be privy to the expectations of TP prior to setting out on teaching practice for better performance in the field.

Regarding the assessment of the PSTs before TP, a few key remarks were recorded from the lecturers;

Lecturer 5: If the student has done dismally in content, she will not proceed to TP. We consider course work, and also sometimes peer teaching, but unfortunately, not all PSTs may end up doing peer teaching, because of limited time. We don't have time for each student, hence, content performance only is considered to proceed to TP.

Lecturer 6 from a different college concurs;

Lecturer 6: Our assessment is based on just, mostly, content. We give them end-of-year exams and if they pass the exam, they can go for TP. If they do not pass, we revisit their areas of weakness so that we adequately prepare them for their pre-service practice.

Whilst lecturer 5 professes that they consider content from coursework, lecturer 6 is talking about content from examinations written. Lecturer 7 also reiterated;

Lecturer 7: Usually, the components which basically constitute passing for TP in our department are 2, (peer teaching and content tests). This contributes to the final assessment. So, they are supposed to pass the two components to go for TP. If they fail, they will repeat.

Lecturer 7 had a slightly different view. Lecturer 7 explained that the assessment included peer teaching prior to TP. Lecturer 6 also talks about revisiting areas that were failed in the pre-TP assessment, whilst lecturer 7 affirms repeating. This exhibits and highlights the different approaches used by teachers' colleges in preparing PSTs for TP. The difference can be an indication of different syllabi applied by various colleges to prepare their PSTs prior to TP.

Generally, the remarks from the interviews indicated that PSTs could only proceed to TP based on their knowledge of the mathematics content and not necessarily pedagogy. For example, students who fail mechanics, statistics and pure mathematics are not allowed to proceed with TP. This is likely to result in pre-service teachers focussing more on content, ignoring the teaching part. According to Makamure [20], content knowledge without pedagogy is futile for a teacher. Makamure [20] contends that viewing one component of teaching mathematics as the only contributing factor of TP effectiveness defeats the goals of effective mathematics teaching. This form of pre-assessment is, however, insufficient to establish competence. According to Mergler and Spooner-Lane [24], problem solving skills enhance intellectual thinking whilst pedagogical teaching practices can assist PSTs to teach effectively for understanding.

Mentors' Preparation for TP Supervision

Ambrosetti [25] contends that participation in mentoring courses can assist in shaping supervision practices. Mentor preparation in this study involves two aspects, namely;

assessment and training of mentors.

When asked if there were any specific requirements before a school-based teacher qualifies as a mentor, college lecturers appreciated the practice of assessing mentors' academic and professional credentials first before practice but observed that it did not happen at their institutions. This is what some of them said;

Lecturer 4: Right, it's just good that we look at the mentors' qualifications and experience. If that teacher has no experience, absolutely he is not going to give adequate assistance to our students….but really, we don't do it here at college "a". We have no assurance for the qualifications, and that's the truth.

Most lecturers concurred that PSTs are deployed to their practising schools without assessing mentors' supervisory credentials. The appointment of mentors was done by their seniors.

The general view of the lecturers was that anyone with a teaching qualification was eligible to be a mentor. This lack of qualification assessment is countered by Peters [26] who poses that universities should address this perceived lack of attention, which is a fundamental field of teacher education. Lecturer 1 also affirmed;

We have problems of teachers especially who have degrees but without a teaching qualification. Especially here in Bulawayo urban. There are mathematics graduates from (University X) without education, so, PSTs are assigned to such mentors, and then at the end, they don't get enough assistance.

It also emerged in the demographics of the study that 10% of the school-based mentors did not have teaching qualifications. The lecturers' views show that assessing mentors' supervisory credentials is vital to the teaching and learning of mathematics by PSTs. During TP, assigning unqualified mentors to PSTs deprived them of the assistance they could have received from qualified and experienced mentors as discussed above. Hollins et al. [10] and Kelly and Tannehill [4] confirm that school-based mentors are normally appointed on a traditional standards basis, which considers only the experience of teaching. The results of the study seem to suggest that mentors' supervisory credentials need some scrutiny and improvement. Failure to assess mentors' credentials may result in PSTs being supervised by mentors with limited capability, hence impeding and stifling the professional growth of PSTs [27].

Regarding training of mentors; lecturer 2 had this to say;

Workshops for school-based mentors are sometimes carried out but the challenge is, not everyone is invited to the workshop. It could be one or 2 members per school who will in turn train others. I feel that this is not adequate because when our students go out on TP, they meet other mentors who have not been trained. To invite everyone, it's expensive for the college.

Generally, the interviews conducted with the school-based mentors also revealed that the mentors lacked proper and sufficient training to equip them with the necessary mentoring skills. Some of them were not privy to the college expectations of mentoring. In order to improve their mentorship, mentors' sentiments were directed towards training, hence one of them said;

M2: … Teachers' colleges should actually brief us on what they expect from their student teachers. Sometimes you just get students, you don't know what the lecturers will be looking for, and you just say, well maybe they need this. Lack of such information actually reduces our confidence and efficiency in supervising. Sometimes you give a mark, say 85%, the college lecturer comes and gives 55%. You see the difference between the two scores. You tend to think you have not done the right thing.

The mentors' remarks were buttressed by the quantitative results of the study which showed that 82.1% of the mentors attained their mentorship skills through experience rather than training as shown in Table 1 below:

Table 1. Mentors' views on TP Supervision

ITEM	N =	Disagree	Neutral	Agree
14. I have received enough training to be an effective mentor	40	(10) 25%	(16) 40%	(14) 35%
15. I gained my skills and expertise in mentoring through experience	39	(0) 0%	(7) 17.9%	(32) 82.1%

Ambrosetti [25] echoes this affirming that in mentoring, mistakes are likely to recur in the absence of proper training. Therefore, without adequate help from the mentors, Mathematics teaching could remain a mammoth task. Endeley [28] affirms that the richness of TP depends on the quality of the supervisor. This implies that failure to train mentors may contribute to the deficiency of mathematics teaching skills among PSTs.

College Supervisors' Preparation for Teaching Practice Supervision

Although some of the lecturers' semi-structured interviews showed that colleges train their staff to enhance their supervisory skills, the fact that the training was quite sporadic was worrisome. According to Anumaka [29] with reference to Teacher Education in Sub-Saharan Africa (TESSA), training of mentors enhances teaching competences in PSTs. Gulmhussein [30] hence, argues that professional development programmes require a significant amount of time to be effective and change teaching/supervision practices. However, sometimes the training becomes futile if it is not put into use. For example, it emerged from the focus group interviews (FGI) with mentors that colleges sometimes send supervisors who do not specialise in mathematics to assess PSTs' work during TP. The practice was viewed as inappropriate for the PSTs in terms of content. Evans *et al.* [31] and Peak [32] hence, assert that subject experts are better positioned to perform supervision activities compared to non-specialists. This is because non-specialist supervisors may fail to give suitable or relevant feedback on the subject content of the observed lessons. Evans *et al.* [31] indicated that non-specialists lack expertise and are not confident enough to assist mathematics PSTs on the subject content since they are inadequately equipped to offer advice.

Resources for Teaching Mathematics

Job Resources – Autonomy

When mentors were asked to explain how often they are together with the PSTs in the classroom for teaching, some of the responses showed that mentors sometimes assume that the PSTs came to reduce their workloads. Therefore, in most cases, PSTs taught mentors' classes on their own. The remarks below were captured from some of the school-based mentors;

M6: I take the student teacher to class, introduce him or her to the class, give them the timetable, the textbooks, and then from there "bye bye" (whole group laughs) and whatever happens, it's between them and their lecturers and the pupils.

Unlike M6, M1 spent some time with the pre-service teacher. This is what he had to say.

M1: Usually, first week, they are observing me teach, and the second week, I am observing them teach. When satisfied he can actually teach, I leave him to teach on his own. I will visit the class here and there to see if there is order and if there are problems, I intervene.

Similarly, M14 affirmed that she supervises PSTs during the first and second weeks of TP and then leaves the class to the PST.

The limited assistance rendered to the PSTs, as reported by the mentors, may defeat the purpose of TP.

The mentors' remarks were concurred by the PSTs when they were narrating their field experiences. Here is what some PSTs said;

A2: I started teaching on the very first day of school. I was even asked to teach without a lesson plan. I requested that she showed me first how to do it whilst I was watching but she declined. She told me first topics in form one are easy and I should be able to teach them easily even without preparation.

Similarly, R3 had this view,

R2: I am not getting adequate assistance from my mentor and I'm being asked to attend the HOD's classes whenever they have a meeting.

Stavridis and Papadopoulou [33] argue that during TP, the PSTs always need support, and reassurance, from the mentors, thus, the mentor should always provide the necessary assistance. The mentors' practices in this study could result in PSTs feeling constrained and denied of their job resource of autonomy at work. However, Rena [21] suggests that while PSTs may need exemplary models throughout the TP period from their mentors, they sometimes need to be independent thinkers, learning and applying theories on their own, hence, equipped with autonomy. This implies that the mentors' practices may turn out to be positive.

Teaching Resources

The responses from PSTs showed that the text book was the most used teaching resource used by PSTs as the instrument of teaching. Their responses, however, revealed that the use of ICT in teaching mathematics was limited. The major reason is that institutions could not afford such resources as mathematics software, computers and other gadgets for use in teaching mathematics. Jarret [34] hence, argues that the use of ICTs turns a teacher into a leading team player in the classroom rather than a sole dispenser of knowledge to the learners, which makes ICTs an essential tool for use in teaching mathematics. Similarly, the college lecturers indicated that PSTs also lacked resources such as teaching media, charts, models and ICTs to facilitate teaching mathematics. The teaching media are considered as the vehicle through which PSTs acquire the means to link with the new knowledge taught. Failure to avail these to the PSTs could compromise mathematics teaching.

4. Conclusions and Recommendations

The results of this study show that TP needs to be

approached in a holistic manner. The findings indicate that the preparation of PSTs, assessment and training of mentors and utilisation of support resources during TP contribute to the structures and tools through which knowledge is shared with PSTs to promote appropriate attributes of learning to teach. Based on these findings, sufficient assessment of PSTs before TP, assessment of mentors' supervisory credentials, training of mentors and sufficient supervision by the mentors are quite paramount and could enhance the theoretical supervisory skills of mentors and hopefully, contribute to augmenting the process of learning mathematics and mathematics teaching among PSTs. To refine supervision, mathematics expert mentors should therefore preside over PSTs' work during TP. This is because non-experts may lack the competence, skill and confidence to assist mathematics PSTs on the mathematics content since they are inadequately equipped to offer content advice.

In conclusion, the inclusion of the most appropriate tools enables PSTs to acquire adequate and relevant skills and competences as a result of TP. The tools, resources and structures suggested in this study are therefore necessary to hoist up PSTs' competences and proficiency in teaching mathematics. It is therefore recommended that the inclusion of such tools in the teacher education syllabi is quite fundamental in elevating mathematics teachers' growth. The tools range from teacher-mentor preparation to the use of essential resources such as ICTs in teaching mathematics. Equipping PSTs with such skills may contribute to effective teaching of mathematics in the country and beyond.

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