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Professionalisation of Mathematics Teacher Educators: Methodology for a Case Study of a Higher Education Institution in Zambia

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Abstract: *Mathematics teacher educators (MTEs) engage in continuing professional development (CPD) through workshops, conferences, research collaborations, and educational technologies. However, research on the long-term impact and underlying processes of teachers' participation remains limited. Additionally, long-term funded CPD opportunities are infrequent, often failing to address evolving technologies and specific needs. Continuing professional development efforts face challenges such as inadequate funding, limited research access, fewer opportunities, lack of initiatives, personal commitment issues and traditional methodologies. This paper explores the methodology from an interpretivist perspective in investigating the professionalisation of MTEs in the context of a longitudinal CPD.*

Keywords: professionalisation, mathematics teacher educators, continuing professional development, interpretivist perspective.

INTRODUCTION

Professionalisation is a process where individuals seek to be publicly recognised as professionals by meeting set criteria such as the improvement in the provision of capacity-building activities to members to enhance the quality of service and in the advancement of members' knowledge and status (Hoyle & John, 2013). According to Hoyle and John (2013), professionalisation of MTEs generally involves in-career professional development initiatives, which significantly safeguards the quality of mathematics teaching and the broader academic environment. In Zambia, the Ministry of Education (MOE) acknowledges that, "the two pillars on which the professional competence of teachers, rest are initial training and ongoing in-career

professional and personal development," (MOE, 1996, p.122). The establishment of the Teaching Council of Zambia (TCZ) and the implementation of the Teaching Profession Act have contributed to professionalism in the teaching profession. However, the concept of professionalism as promoted by the Teaching Profession Act and the Teaching Council of Zambia is more to do with the code of conduct rather than competence (Simuyaba & Chibwe, 2016). Avenues with an elaborate structure for continuing professional development (CPD) for teachers through the School Programme of In-service Training for the Term (SPRINT), and Zambia Education Enhancement Project (ZEEP), have positively affected teacher classroom practices and student learning outcomes (Mubanga, 2012; World Bank Group, 2020).

Teacher educators are responsible for the CPD of teacher education. They are also the main agents of change in facilitating the 21st century concept of lifelong learning, which has become central to professional development and curriculum. Yet, they do not have access to CPD avenues with elaborate structures (Dengerink et al., 2015; Loughran & Menter, 2019). Additionally, research into educators' CPD interventions, particularly in mathematics education is inadequate due to lack of funding (Addai-Mununkum, 2023; Wolkenhauer & Rutten, 2025). Moreover, the effectiveness of their CPD programmes is often hindered by weak organisational support, inadequate funding leading to persistent insufficient learning resources, poor methods of instruction, old methodologies and curriculum, lack of technological proficiency and adaptability (Forde & McMahon, 2019; Luneta, 2024; Mitchell et al., 2024; Mukuka & Alex, 2024).

In response to the sporadicity of CPDs and challenges faced by MTEs' in accessing CPD opportunities, the European Commission (EC, 2013) is implementing Professionalisation of Teacher Educators in English and Mathematics (ProTEEM). This is one of the long-term initiatives to provide CPD interventions to teacher educators in Zambia, to ultimately enhance students' academic equity and success. Literacy and numeracy are fundamental skills that the Commission prioritises and, by capitalising on the multiplier effect of teacher educators (train-the-trainer and trickle-down effects), they aim to equip novice teachers with the tools needed for lifelong learning and active participation in society (European Commission/EACEA /Eurydice, 2021). This will be done through a longitudinal intervention that aims to: 1) improve the quality of teaching in English and mathematics, 2) promote gender equality through education, 3) reduce poverty by ensuring access to quality learning experiences, 4) encourage innovative teaching methods that meet diverse learning needs, such as training workshops, blended learning approaches that integrate digital tools with traditional teaching methods, collaborative research to develop innovative teaching strategies, mentorship programmes to support teacher educators in their professional growth and curriculum development (EECEA, 2021).

To generate empirical longitudinal data on the effectiveness of the CPD intervention, a study is needed to investigate the professionalisation process and the trickle-down effect on the teaching practice of secondary school students. The research questions to be answered are: (a) What factors influence the professionalisation of MTEs in the context of a longitudinal CPD?

(b) How does the professional identity of MTEs develop over time in the context of a longitudinal CPD programme in Zambia? and (c) How does this longitudinal CPD programme contribute to the learning outcomes of students based on their educational experiences (trickle-down effect)? This paper provides the methodology to be used for the research.

Research Paradigm

To address the research questions, the interpretivist paradigm will be employed. A paradigm is a belief about the nature of knowledge, a methodology and criteria for validity (Thanh & Thanh, 2015). It consists of ontology, epistemology and research methodology (Scotland, 2012). Ontology can be referred to as the "study of being" (Crotty, 1998, p. 10). Epistemology is concerned with the "nature and forms of knowledge" (Cohen et al., 2007, p. 7). Methodology refers to what will guide the researcher on how to find out what needs to be known (Scotland, 2012). The researcher will strategise, make a plan of action and choose particular methods of data collection (Crotty, 1998). Thus, methodology is concerned with "why, what, from where, when and how data is collected and analysed" (Guba & Lincoln, 1994, p. 108).

Therefore, this research study will employ the interpretivist paradigm with its underlying principles: (1) reality is socially constructed (Willis 2007), (2) the belief in understanding "the world of human experience" of a particular context (Cohen & Manion, 1994: p36), and (3) understanding phenomena from an individual's perspective, investigating interaction among individuals as well as the historical and cultural contexts, which people inhabit (Creswell, 2009). When applied to CPD, the paradigm provides a lens through which a researcher will mirror how professionals perceive and engage with CPD learning experiences, focus on understanding their subjective meanings, and explore how individual MTEs interpret phenomena rather than seeking universal laws.

Instead of measuring CPD effectiveness through standardised metrics, the researcher will explore the personal and contextual factors that shape professionalisation, as the paradigm acknowledges that CPD is influenced by individual motivations, workplace culture, and broader social dynamic experiences (Pervin & Mokhtar, 2022). The ontological assumptions of what constitutes reality are implicit in the researcher's quest to reveal reality by exploring the various dimensions that the CPD programme encompasses, and the factors that influence professionalisation over a period of two years (EC, 2013; Scotland, 2012). The researcher is motivated by the need to understand the context of the programme and answer questions such as, what are the characteristics of a CPD project? How is the CPD tailored to meet the evolving needs of teacher educators and students? These are examples of some ontological assumptions that the researcher can investigate and construct a detailed exploratory analysis of specific events such as CPD curriculum and activities, CPD deliverables, the evolving experiences of MTEs, reflections and how the knowledge acquired is integrated and implemented in everyday practices (Schoch, 2020).

The interpretivist' epistemological assumptions about how knowledge can be created, acquired and communicated and what it means to know, will be explored in the way that participants in

the CPD programme will interact with the materials (Guba & Lincoln, 1994). Close contact with the participants will allow the researcher to provide a detailed account of their behavioural aspects, their activities in the CPD curriculum, their reflections and feedback, and their transition will be described in detail as the nature of reality (Allison & Pomeroy, 2000). Furthermore, the fact that people differ from physical phenomena and that they cannot be examined in the same way, means that reality is subjective and can differ based on different individual experiences (Pius & Alharahsheh, 2020; Scotland, 2012). This implies that research participants may not be able to provide general interpretations of their experiences from the CPD training programmes. This understanding prompts the researcher to adopt a qualitative approach to gain an in-depth understanding based on each participant's experiences with less generalisation (Easterby et al., 2008).

Research Design

Because the study focuses on understanding changes in participants' perceptions, experiences and social contexts, a Longitudinal Multiple Case Study Design (LMCSD) is appropriate to track how the experiences of each of the MTEs evolve over time (McLeod & Elliot, 2011). Case studies typically enable a researcher to describe a phenomenon, explore a phenomenon, or produce an explanation of a phenomenon (McLeod & Elliot, 2011). According to McLeod and colleagues (2011), longitudinal case study data is collected over an extended period of time to investigate "how certain conditions change over time." Case studies typically look in detail at how change unfolds over time, based on a series of multiple observations (Yin 2003, p. 42). Hence, this study is an example of an in-depth, holistic case study within the interpretivist paradigm as it is based on examining the professionalisation of MTEs over a 2-year period and it is appropriate to be conducted longitudinally to facilitate a "multifaceted treatment of change" in MTEs (Pettigrew 1990, p. 270).

In order to provide rich descriptions of ontological realities such as: participants' current professional knowledge/beliefs, opinions, their practices, interactions, internalisation and integration of pedagogical/content knowledge, their perspectives in the context of the longitudinal CPD trainings, a LMCSD is suitable to enable the researcher to uncover such diverse insights (Allison & Pomeroy, 2000). This implies that most of the data collected is qualitative in nature, as this study shows a general absence of quantifications and statistical procedures (Strauss & Corbin, 1990).

Normally, a case has a defined space and time frame, which is why the researcher situates the study as a longitudinal case study design. For instance, the professionalisation of MTEs in Zambia, in the context of CPD, over two years, is a "phenomenon of some sort in a bounded context" (Miles et al., 2014, p. 28). In terms of scope, a case study is an in-depth investigation of a contemporary phenomenon within its real-life context and is relevant to apply to an investigation into the practice of MTEs as they continue their teacher education by providing professional development and preservice training (Schoch, 2020). A case study provides a comprehensive understanding of a bounded unit and helps the reader to examine that case so that he or she can learn from it (Schoch, 2020). In terms of outcome, it also allows others to

apply the principles and lessons learned to other cases or situations and leads to transferability (the ability to apply the case to another situation) (Street & Ward, 2012). The researcher also situates the study as case study research as it offers a degree of flexibility. In this sense, it is likely that the key parameters of the research design may be altered during the 2-year study period in order to react or adapt to "the complex and dynamic characteristics of real-world phenomena" (Runeson & Host 2009a, p. 137).

Population

The target population consists of all MTEs in colleges and universities in Zambia, who are currently offering mathematics as a teaching subject to both in-service and preservice teachers. The population under consideration will help to describe reality, given the assumptions and beliefs of the interpretivist understanding (Remenyi et al., 1998). According to Kothari (2014), it is appropriate to target a population that the researcher has in mind from which information could be obtained and draw conclusions. Thus, only a minimum but acceptable small sample will be taken from a large group of MTEs in Zambia (Merriam, 1998).

Study Area

The choice of the study site in Zambia is based on the project's objectives, namely to professionalise MTEs from one of the universities, taking into account the opportunities and challenges identified in the context of low- and high-income countries (EC, 2013). The choice of the study area is also based on the institutions' tradition of providing high quality education and research in teacher education, combined with the participants' experiences in providing secondary mathematics education (EC, 2013).

Study Sample

White (2003) defines a sample as a segment of the population that is selected for investigation. The sample size will consist of 4 MTEs in the CPD who are offering mathematics courses. By exploring each individual's participation for this sample size, the researcher can examine in-depth experiences of how participants individually integrate new content and pedagogies into their classroom practices (Moustakas, 1994). According to Merriam (1998) and Creswell (2014), this is a reasonable, contextually, limited sample size for qualitative data and a case study approach because it provides data needed to fulfil the requirements of efficiency, representativeness, reliability and flexibility.

Sampling Techniques

Based on the given context, the researcher considers several factors when analysing the effect of MTEs' participation in the programme: the mode of delivery, the materials and the behavioural aspects based on the experiences of each participant (Miles et al., 2014; Scotland, 2012). Therefore, the researcher's goal is to have experts: qualified and experienced MTEs who have rich teaching experience in HEIs and are participating in the CPD programme. This decision is in line with Cohen et al., (2007) who argue that the social world can only be understood from the standpoint of individuals who are participating in it. Scotland (2012) also

highlights that interpretivist's view the world through a series of individual eyes and choose participants who have their own interpretations of reality to encompass the worldview.
By using expert, purposive sampling to select participants, the researcher believes that MTEs will be able to actively reflect on their expertise, seek feedback from colleagues, engage in activities that build upon their existing knowledge and skills, provide rich information from which one can learn much about issues of crucial importance to the research and focus on a phenomenon in depth (Patton, 2002; Yin, 2018). According to Tongco (2007), the purposive sampling technique (also called judgment sampling) is the conscious choice of an informant based on the qualities the informant possesses.

Data Collection Methods and Procedure

Data collection methods will include open-ended questions, documentation/archival records analysis, personal interviews, direct observation and focus group discussions (Yin, 2018). According to Willis (2007), the idea of using various methods arises from the belief that external reality is variable; there are multiple perspectives. Willis goes on to indicate that "different people and different groups have different perceptions of the world" (p.194). The acceptance of multiple perspectives in interpretivism leads to a more comprehensive understanding of the situation by integrating different ways of arriving at what needs to be known (Willis, 2007).

For instance, by observing participants in their classroom learning during the CPD trainings, the researcher will immerse and understand the content, pedagogy, technology and tools being used in the process of knowledge construction (Saunders et al., 2012). Semi-structured interviews, focus group discussions, and open-ended questionnaires will elicit responses from which further understanding and meaning of their experiences will be derived in a flexible way of data collection (Pius, 2020). This understanding fits within the interpretivist's paradigm and the case study design, as the inter-subjectivity concept of the knowledge construction process can only be explored when participants engage in confrontational questions and direct observations (Flick, 2006). This also gives the researcher the opportunity to seek both clarification and elaboration on issues raised from these sources of data and gather more information regarding a particular phenomenon (training program), beliefs, views, opinions and experiences (McLeod et al., 2011).

In order to understand the subjective experiences and social realities of each individual's participation in the CPD programme, the researcher will use open-ended questions before each training session to collect baseline data about their previous experiences, personal CPD perceptions, expectations and current knowledge. Since they are experienced MTEs, their prior professional knowledge in teaching at a HEI is relevant for reference while monitoring their progress in the training. Thus, after each training session, new follow-up open-ended questions will be administered to the participants to gain information about their experiences after each CPD session. The open-ended questionnaires will be used to collect data on individual endeavours, CPD opportunities, challenges, collaborative practices, and how they will manage the CPD structure and implementation process.

Secondly, the researcher will use document analysis protocols of the following: mathematics education curriculum used by teacher educators and the CPD curriculum, lesson plans, worksheets, CPD training materials and texts/email communications. Document review of the brochures or training manuals can assist in interpreting the meaning, relevance and suitability of the reality of the CPD training programme. These documents may offer deeper insights on the various activities that the programme encompasses and how these will foster or constrain the knowledge construction process (McLeod, 2011).

In addition, the researcher will also use direct observations to collect data on the development of pedagogical content knowledge, the use of different strategies, methods, and techniques. Data will also be collected on the application of project-based learning, and the use of technological applications. The effectiveness of presentations and the structure of the professional development programme. By directly observing the CPD sessions and professional learning activities, the researcher can gain first-hand experience from the participants and gain further insight into the training processes, participant participation and effectiveness. According to Kothari (2014), the observational method seeks information through direct observation by the researcher without asking the respondent. The researcher will participate in the study for as long as possible, interacting with the project participants and CPD providers and collecting data with their knowledge (Tolich & Davidson, 1999). By personally experiencing the research context of the CPD conditions, the researcher will be able to gain sufficient contextual knowledge to interpret what is observed and facilitate the development of an in-depth understanding of the participants, experiences, events and activities (Walsham, 2006). In this case, biographies of CPD providers and MTEs, their opinions, experiences, values, aspirations, attitudes and feelings will be expressed in depth (Creswell, 2014).

After each lecture of the MTEs, focus group discussions (FGD) are held for the teacher training students. This will help the researcher to better understand collective experiences and insights about programme outcomes, didactics and CPD transfer intentions (McLeod et al., 2011). In addition, the researcher will use face-to-face interviews and a list of semi-structured questions to interview participants (MTEs) at the time they are teaching their students. The interview will be conducted using an open and flexible questioning technique as this provides better access to the interviewees' views of the CPD programme, interpretations of training events, understanding, experiences, opinions and implementation (Pius, 2020). The researcher will use different interview questions to ensure consistency of interviews among interviewees depending on their experiences. Pius (2020) suggests that a researcher can also use different interview protocols for different groups within the case. For instance, different interview protocols can be used for each of the MTEs and students or other participants within the study (Pius, 2020).

Each of these methods will provide an in-depth insight at the CPD programme: the diverse experiences of each MTE, their interactions with the CPD providers, their student teachers, and the integration of content, pedagogy and technology into their practice. The ontological

emphasis is that reality is not fixed, but socially constructed through interactions (Ernest, 1996). This prompts the researcher to closely observe MTEs' direct interaction with new activities, responses, participation, their ability to integrate new content/pedagogical strategies and technologies into their practice. It also stimulates their collaborative elements with other communities of practice, mentors, stakeholders as well as their reflections and feedback on improving the learning experiences and CPD transfer. Video cameras and diaries will be used during direct classroom observations. An audio recorder will be used when conducting semi-structured interviews and focused group discussions with MTEs. Dawson (2002) suggests that when using a voice recorder, it is important to hear your own voice and that of the interviewee so that you know what answers were given to what questions.

Data Collection Timeline

The researcher plans to collect data as soon as the commencement of the CPD trainings from March 2024 to December 2025. Data collection will begin with reviewing documents in order to understand the objectives and contextual relevance of the CPD to Zambia's current needs. Before each scheduled training session, the researcher will establish the MTEs prior knowledge and the context of their teaching through semi-structured questions. During and after each training session, the researcher will follow up the MTEs in their respective classrooms to observe and conduct FGDs with students. This will be on how they experience and integrate new knowledge into practice before the next training begins. The procedure will be a cycle until students seek teaching experience in the field. The researcher will conduct at least 12 classroom observations per semester, and 5 focus group discussions with the 8 pre-service teachers from a selected HEI in Zambia, who will be followed for observation during their teaching experience.

Data Analysis

Preliminary data analysis will begin early in the project and continue during and after field work and after as required. Street and Ward (2012) argue that the methodology of longitudinal case studies differs from that used in general case studies because it includes an additional step in the data analysis procedure. That is a timeline of events or a series of changes in research variables over time, created from the dataset as the basis for the case study narrative. During data collection, data will be synthesised by identifying patterns at each stage of the CPD event without losing its richness (Dawson, 2002). The data collected will be sequential, in line with research objectives and will differ depending on each stage of the CPD training sessions and time. Dawson (2002) states that, for qualitative data, the researcher can analyse data as the research progresses, continually refining and reorganising it in light of emerging results and time.

Data collected through open-ended questions, lesson observations, semi-structured interviews (face-to-face), document analysis and FGDs will be analysed vertically in accordance with each method, and horizontally across all research methods in accordance with the research questions. Horizontal analysis will generate themes from the datasets for the initial training experiences and during the fieldwork before the next training begins (Creswell, 2014).

Therefore, thematic analysis will be used in the study. During the analysis, data captured from lesson observations (video lessons), interviews and FGDs (audio recordings) will be transcribed, edited, coded, categorised, and tabulated according to the research questions (Kothari, 2014). The researcher will compare and converge what the MTEs will answer in open-ended questionnaires, in a CPD session. That is, what will be said during interviews or FGD, during their practical lesson, and what will be observed when conducting document analysis (Patton, 1999). This will help the researcher develop a comprehensive understanding of the phenomenon and test its validity through the convergence of information from different sources (Doolin, 1996). Data will be coded according to research questions and then categorised according to similar patterns of ideas for research questions. Themes will then be generated from categorised ideas. The following is the procedure for generating themes from the coded and categorised data during data analysis.

Step 1: Become familiar with the data.

The researcher will delve into the data to understand its depth and nuances by reading and re-reading the transcripts multiple times (McLeod et al., 2011). The researcher will start by familiarising him or herself with the depth and breadth of the entire dataset of open-ended questions, observations, transcripts of interview recordings, document analysis and transcripts of FGD recordings. The transcripts will also be checked for accuracy against the original audio recordings.

Step 2: Generate initial codes

During this phase, data will be organised in a meaningful and systematic way (Braun & Clarke, 2013). The data will be coded (reduced) separately into small chunks of meaning based on the set perspective and research questions. Codes will be reviewed by other researchers for robustness and credibility. They will be compared and adjusted when necessary.

Step 3: Search for themes

In this phase, the codes will be examined to clearly fit into specific themes and subthemes that speak specifically to the research questions (McLeod et al., 2011). Related patterns between codes will be grouped together so that they represent similar ideas or experiences of the participants. Initial data will be broadly categorised in the context of MTEs' professional experiences, which will be identified from participants' responses (McLeod et al., 2011). For ease of management, extracts from the data relating to each initial category will be identified in a separate document by reference to their source, such as the date of collection and page number in a field notebook, and electronic source document. Where a data extract is considered relevant to more than one category, it will be included in multiple locations (Whittle, 2005). Cross-references will be made between different categories to reflect and enhance their interrelationships and interaction. Data within each initial category will be read and re-read multiple times, separated by significant time periods. In this part of the analysis, the data will be categorised and re-categorised using a process of constant comparison to identify more refined themes based on specific aspects of how the project will be carried out (McLeod et al., 2011).

Step 4: Review themes
The themes in phase 4 will be reviewed, modified and developed. All data relevant to each theme will be collected. The researcher will reread the data associated with the themes and consider how valid they are with the entire dataset. These will then be coded any additional data within the themes that may have been missed in earlier coding phases. The themes will be derived primarily inductively from the data (Walsham, 2006).

Step 5: Define themes
The themes will be defined and refined in order to identify the essence of each theme (Braun & Clarke, 2006). The researcher will explain what each theme means and how it helps to understand the data and give each theme a short, clear descriptive and accurate name (Braun & Clarke, 2006, 2013). By consistently considering the feedback, perspectives and experiences of participants, themes will be assessed. Those that are coherent from the coded data will be combined or form sub-themes. Illustrative quotes from data will be included to clarify the themes.

Step 6: Writing-up
The final phase will involve writing the thesis on the findings. The analysis will provide a concise, coherent, non-repetitive, logical and interesting account of the data within and across themes with significant evidence. It will illustrate the contribution of practice-related learning opportunities and outcomes of the professionalisation process to the development of teacher educators based on empirical longitudinal data that will be generated.

Validity and Credibility
Street and Ward (2012) have highlighted the need to improve the validity and credibility of LMCSD research. The validity of timelines created from longitudinal data is necessary because time changes participants' perceptions and feelings (Street & Ward, 2012). For example, Schonfeld and Rindskopf (2007) point out that some longitudinal case studies do not explicitly recognise time as a variable within the research design. However, in this study, time is considered by keeping track of where we are and what we are doing, knowing that time passes at different rates and with different salience for each individual's experiences over time (Street & Ward, 2012). Miller (2008, p. 226) claims that, "triangulation provides an explicit vehicle for tackling the principal issues or limitations presented by a single empirical study." Thus, the researcher will ensure credibility by cross-checking data from multiple sources, seek feedback from participants, share the preliminary findings with MTEs and other stakeholders to confirm the accuracy of the interpretations in order to validate and refine the conclusions (Miller, 2008).

Ethical Considerations
All necessary ethical approvals and consents are underway. Considering that this is an international CPD, the researcher will be culturally sensitive by considering the cultural context and dynamics of onsite training from Lithuania, Belgium and South Africa and will adapt the research approach accordingly (Arifin, 2018).

CONCLUSION

The professionalisation of MTE initiatives within the framework of a longitudinal CPD programme shows a promising avenue for improving the quality of mathematics education in Zambia. The programme appears to be a transformative process that can improve teaching effectiveness, foster innovation, promote equitable learning opportunities and overcome challenges. Inconsistent training frameworks, lack of financial and policy support, and resistance to change necessitate strategic interventions to ensure sustainable professional growth. This case study methodology is crucial for investigating CPD roles in higher education institutions and how CPD promotes sustainable professional growth are some of the challenges, reflective practice and collaboration among teachers. The methodology provided is an important basis for developing a proposition that analyses extensive empirical data on how CPD addresses challenges such as limited resources, institutional support and alignment with educational goals. Ultimately, this methodological approach can not only equip researchers with qualitative research skills but also highlights the need for an exploratory process for the professionalisation of MTEs in Zambia.

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