Mathematics Student Teachers' Conception of Learning Mathematics

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ABSTRACT

This qualitative case study explored early conceptions of mathematics learning among 36 third-year mathematics student teachers. Data were collected via open-ended questionnaires and follow-up interviews, then analyzed through a constructivist lens. The findings revealed that the student teachers predominantly viewed mathematics learning as: (a)Passive reception of information rather than self-directed knowledge construction and (b) memorization of facts/procedures over reasoning and making sense of mathematical ideas or relational understanding. Without explicit intervention, these conceptions risk perpetuating transmission-based teaching models that undermines the development of mathematical reasoning. The study provides mathematics teacher educators with critical insights for redesigning mathematics teacher education strategies and practices which would contribute to reshaping unproductive conceptions of learning mathematics that may exist.

Keywords: Mathematics student teachers, conceptions, Mathematics learning

INTRODUCTION

Teacher education have a responsibility to prepare student teachers who can teach effectively (Sandholtz, 2011). This is generally done through providing: general knowledge and skills for teaching, specialised knowledge and skills as linked to student teachers' subject of specialisation and a foundation for their continued learning. Teacher education also has an influence on student teachers' conceptions about education, its purposes and practices. Literature such as Tatto (1998); Laursen (2008); Monteiro, Mata and Santos (2021) show that the influence of teacher education on student teachers' conceptions about education is a multifaceted process that shapes their understanding of teaching roles, educational purposes, and classroom practices. Cheng, Tang and Cheng (2016) in their study on student teachers changing conceptions have argued that understanding student teachers' conceptions and development of conceptions of teaching and learning is crucial for teacher educators to explore. This can be generalised and or specifically applied to specific subject matter such as mathematics in this case. An understanding of student teachers' conceptions about teaching and learning mathematics can help in improving student teachers' learning and preparation to teach. It can be '…a valuable tool for improving effectiveness of teacher education in general and student's learning in particular…' (Dejene, Bishaw & Dagnaw, 2018, p.174).

Conceptions of learning Mathematics

Crawford, Gordon, Nicholas and Prosser (1994)'s study is among studies that have investigated student's conceptions of mathematics and how it is learnt. They found a relationship between students' conception of the subject and students' approach to learning in the subject. Their findings show that students with a fragmented conception were likely to use a surface approach to their study, while those with a cohesive conception were more likely to use a deep approach to their study. Yang, Leung and Zhang (2019)'s study is another example of a study that investigated students' conceptions and approaches to learning mathematics at

secondary school level. The findings of this study review seven dimensions of conceptions of learning Mathematics which are put in two categories of: lower-level and higher-level conceptions and are said to follow a hierarchical order (Yang, Leung, & Zhang, 2019). The lower level conceptions include: (a) memorising; (b)testing; and (c) calculating and practicing and it is argued that represent a more passive and fragmented view of learning (Kember & Watkins, 2010 as cited in Yang et al., 2019). The high-level conceptions of learning which include mathematical thinking emphasize understanding and sense-making through connecting new information to knowledge that the learners already have and also applying knowledge or information acquired which prior relates to the constructive view of learning (Peterson, Brown & Irving, 2010; Matthews, 2000). These studies provide some evidence of the correlation between students' conception of Mathematics and their approach to learning it.

There are some studies related to mathematics student teachers that have been conducted in Zambia among them: Changwe (2017); Chabulembwa (2014) and Nalube (2014). However, these studies do not have a specific consideration of student teachers' conceptions of teaching and learning mathematics. There is a dearth of research in the Zambian context with a focus on the interaction between student teachers' conceptions about teaching and learning and teacher preparation in general. More specifically, there is a scarcity of research in the Zambian context with a focus on the interaction between student teachers' conceptions about teaching and learning Mathematics and (content of) teacher preparation programmes. This was the direction or focus for the Masters in Mathematics Education programme from which this manuscript was drawn. The overall purpose of the Masters study was to explore mathematics student teachers' early conceptions of mathematics teaching and learning for improved mathematics teaching and learning experiences. Four research interrelated questions were posed to guide the study. This manuscript focusses on two of the four interrelated research questions from this study. The two research question were: 'What are mathematics student teachers' early conceptions of learning mathematics? and 'What are mathematics student teachers' conceptions of mathematics'?

METHODOLOGY

This study adopted the qualitative research approach with a single case study research design. The population for this study was all the 47 third year Mathematics student teachers at Kwame Nkrumah University (KNU) in Kabwe, Zambia.

Background of the study participants' teacher education programme

In Zambia in general student teachers take compulsory education courses which relate to educational theory and practice. The courses are designed to provide general knowledge and skills for teaching and a foundation for professional growth and development (Banja & Mulenga, 2019). They also take courses that specifically relate to their teaching subjects of specialisation. It is expected that through these courses, they will develop specialised skills and knowledge relating to in-depth content area of the teaching subject (s) they have chosen to specialise in. At KNU in particular, student teachers were expected to add on what are generally considered as methodology courses (Nalube, 2017) in the third year of their teacher education programme. These courses are designed to contribute to the development of pedagogical content knowledge which include techniques, strategies and procedures for teaching and assessing the content of the chosen subject of specialisation. It is also in these courses that they are expected to do peer teaching as part of preparation for school teaching practice-STP- (or practicum). A student who has not taken these methodology courses can not be allowed to proceed and go for their STP. The third year mathematics students, and not fourth and final year students, were chosen because their conceptions of teaching and learning mathematics had not been influenced by the learning of the mathematics methodology courses, peer teaching and school teaching practice compared to the fourth years. The data for this study was collected before they commenced learning their third year courses.

The questionnaire with open-ended questions was distributed to all the 47 student teachers with Mathematics as the chosen area of specialisation as key participants. However, only 36 (out of 47) questionnaires were completed and received back, giving a response rate of 77%. Based on this, the sample size was 36. Fourteen

(39%) out of the 36 who completed the questionnaire indicated that they were willing to participate in the one-to-one follow up interview. This formed the basis of the decision to include them among those to be interviewed. The researcher was also conscious of saturation point as explained by scholars such as Saunders, Sim, Kingstone, Baker, Waterfield, Bartlam,... & Jinks (2018) when interviewing the student teachers. Only 2 out of the 4 Mathematics teacher educators were willing to be interviewed and data collected from them was only used for crosschecking that from the student teachers. Data collection methods for the bigger study encompassed questionnaire, interviews and document review. However, data for this paper was drawn from questionnaires and interviews. The study used thematic and content analysis in the analysis of data collected and in the light of constructivist theory.

PRESENTATION AND DISCUSSION OF FINDINGS

The student teachers shared their conceptions of Mathematics and of learning Mathematics on the questionnaire they completed and some also elaborated on their points during the follow-up interviews. The findings that related to their conceptions of Mathematics are presented below first.

Conceptions of Mathematics

In their responses, as presented through the questionnaire and interviews, the mathematics student teachers shared their conception of Mathematics and of learning Mathematics. They also shared what this meant to them at present and in relation to their expected future work as teachers of Mathematics. An analysis of their responses on the questionnaire and interviews led to the following themes and categorisation of their understanding of the nature of Mathematics; Numbers, Subject/course, Cognitive/cognition and language. Table 1 below shows the themes each with its respective subthemes and number of times mentioned on the questionnaire. The fourth and last column of the Table has examples of the excerpts from questionnaire/interview with respect to each theme.

Table 1: Student teachers' conceptualisation of Mathematics

Theme	**Some key words mentioned representing theme**	**Frequency**	**Example of excerpts from questionnaire/interview**
Numbers	Numerical in nature/Numerical data (11): Calculations/Calculations of numbers (8): Numbers and letters (8): Numbers and operations (6): Statistical data (3): Numbers and symbols (2)	36	*'It is about numbers'* STQ1 *'…numbers and symbols make mathematics…'* STQ47 *'Mathematics deals with numbers and the four operations…'* STI9 *'Mathematic is about numbers, letters, shapes, patterns and how they are connected or their relationship…'* STQ39.
Subject/course	School Subject (12): Subject involving calculations/numbers (11): Academic subject (6): Practical subject (3)	32	*'…it is an academic structure that deals with numbers and how ideas relate through numbers, rules and calculations…'* STI10 *'Mathematics is an academic subject is that deals with numbers and rules to be applied…'* STQ13 *'Mathematics is s a science subject...'* STQ37
Cognitive or cognitive-oriented	Involves thinking/Critical thinking/logical thinking	16	*'Mathematics deals with analysis, interpretation and evaluation of*

	(7): Critical reasoning/reasoning (5): Analytical in nature/Analysis(3): Mental engagement (1)		*numbers…different types of numbers…*'STQ5 *'It is about thinking…thinking critically and logically and numbers for correct calculations…'* STI3
language	Science language/language of science (4) Language of problems/Language for solving numerical problems (2): Language of mathematicians (2) Language for explaining numbers (1)	9	*'it is a language of science...'* STQ15 *'It is a scientific language which helps us to understand and solve numerical problems in the subjects we learn…'* STI10

Source: Field Data

The student teacher study participants expressed several different held conception of Mathematics. This partly confirms Berlinghoff, Grant and Skrien's (2001, p. 1) argument that '…the many diverse ideas [about what Mathematics is] defy simple description.' That stated, some of the conceptions of mathematics shared by the student teachers are in line with: Jourdain (2013: p5) who argues that 'mathematics is logical'; Berlinghoff et al (2001) who state that mathematics is both a science and art and: Loucks-Horsley, Stiles, Mundry, Love and Hewson's (2010) argument that Mathematics involves complex reasoning, problem solving, analysis and communication of patterns and relationships in a logical manner.

The student teachers' conceptions also give a general indication that mathematics has been described more in terms of what it encompasses as an academic subject involving calculations than involving reasoning and with practical application in real life. They are missing out aligning with definitions such as by Berlinghoff et al (2001) who also states that Mathematics is a way of thinking about the rapidly changing world we live in and is a problem-solving tool for real life problems.

Another interpretation is that one's understanding of mathematics can inform or shape one's conception of teaching and or learning Mathematics. For instance, if a (student) teacher believes that mathematics is about numbers (figures) alone, they may find themselves struggling to teach or learn or do word problems which may be language intensive. 'When mathematics is regarded … as a set of rules governing symbols, students tend to consider doing mathematics as the memorization of algorithms and the learning process as a process of transmission argues Wong (2002, p. 211). Hence the need for teacher education programmes to assess and consider student teachers' conceptions in their curriculum as it could inform preparation of student teachers to learn for themselves and for effective teaching upon completion of their training programmes.

Conceptions of learning Mathematics

Three main themes that emerged from the analysed responses in the questionnaire and interviews on learning Mathematics were: being taught, practising and memorizing. Below are examples of excerpts, under each theme, of what was written or said to this effect.

Being taught

Most student teachers argued that they have to be taught for them to learn Mathematics. One student wrote on the questionnaire that: *'…it is best to wait for the teacher to show what to do… that is how we can learn, otherwise I can end up studying something else…'*STQ2. Another student stated during the interview that: *'…teachers are there to teach and learners are there to learn from the teachers… and teachers have to confirm like by marking work that work has been correctly done'* STI11.

Attendance of teaching/lecture sessions and listening attentively to lecturers' explanation or teaching/lecturing can support students' learning of Mathematics (Chabulembwa, 2014; Wicks, 2014). However, scholars such as Voskoglou (2019) also argue that a lecturer's ways of teaching also matter as some ways of teaching may

largely promote procedural knowledge at the expense of promoting conceptual knowledge, critical analysis, reasoning skills and self-directed learning skills among others. Analysis of student's responses show that students' conception of learning of Mathematics is that which is associated more with the teacher/lecturer in order to learn minus considerable accommodation of the possible limitations associated with the lecturer's way(s) of teaching. In this case in particular, students' attention to the place and function of self- directed learning/independent learning/independent studying is largely not regarded. Despite its limitations, self-directed learning has its place in the learning of mathematics (Istiqlal & Himmah, 2019) and is to be encouraged at university level. In the case of students in the study it may be that students over depend on the lecturer for them to learn and fail to take initiative to be actively involved in their own learning and learning process. Such a tendency could hinder their development of instructional skills for facilitating learning later on in their teaching career. The development of self-directed learning skills may have to be supported too.

Memorising

Memorising as a way of learning Mathematics was mentioned by nearly all student teachers. One stated that: *'…one can't run away from memorising in mathematics. …there are formula and the rest which if you don't memorise one can even find themselves failing'* STI10. Another student teacher indicated that: *'Maths and memorising go together…'*STQ45. One lecturer confirmed this about the student's way of learning mathematics and lamented that *'this negatively affects their developing of mathematical reasoning they are expected to develop…*'LI2. The findings also show that student teachers' conceptions of learning mathematics was more in line with memorizing mathematical facts, rules and formulae largely devoid of reasoning and making sense of mathematical ideas and exploration of their relations. It is argued that this is in some way(s) connected to the view that '…mathematics is "given" or "fixed" for students' expected acquisition …' Li and Schoenfeld (2019, p. 1) with little or no element of students figuring out or creatively making sense of it. While memorising may have its place in learning some mathematical concepts, scholars such as Yang et al (2019, p. 2476) argue that it is one among mathematics learning strategies that '…represent a more passive and fragmented view of learning which considers learning more as a process of copying and reproducing information that requires to be learnt' and hence categorised as lower level conception of learning. They continue to argue that engaging in higher level conceptions of learning such as mathematical thinking, among others, would be benefit student learning more. This is because such emphasize understanding and sense-making through connecting new information to knowledge that the students already have and also applying knowledge acquired (Peterson, Brown & Irving, 2010; Matthews, 2000). If students' view and conception regarding memorising as a way of learning remains as is, it may negatively affect student teachers' learning of mathematics and cause them to also develop instructional practices that present mathematics as such in the field upon completion.

Practising

Almost all the students made reference to practising given/taught procedures as being a way for learning mathematics. For instance, one student teacher indicated that: *'maths can't be learnt just by looking at it…one has to do maths to learn maths…'* STI3 Another stated *'…answering questions like the ones given in class after discussing the examples … is all part of practising…'* STI9. One lecturer emphasised this point on practising, by stating that *'…practising to handle different mathematics problems has a way of helping students apply the mathematical concepts learnt…and actually see how the different concepts are connected…'* LI1.

The student teachers shared what their conceptions of learning mathematics were and made reference to what this meant to them in terms of learning mathematics at present and in relation to their future learning and work as teachers of Mathematics. Their responses, are in line with other students' such as those in Wick's (2014) study in the United Kingdom and Chabulemba (2014) in Zambia, who generally identify practicing solving mathematics problems as a way of learning Mathematics. Students can practice solving mathematics problems as individual and or in groups. Practice solving mathematics problems can increase competence in dealing dealing with mathematics problems (Kaiser, Schwarz & Buchholtz, 2011) especially if it is cumulative practice of components of what is being studied (Mayfield & Chase, 2002). There is more to practising mathematics

as a way of learning mathematics that the students may need to be exposed to for effective Mathematics learning. Studies such as Sweller, Clark & Kirschner (2010) and Renkl (2017) explain this as they emphasise the benefit in students practising mathematics through studying worked examples which go beyond that of simply practising working/solving mathematics problems as a way of learning mathematics.

LIMITATIONS OF THE STUDY

One of the limitations of this study is that the findings of this qualitative study cannot be generalized beyond the population of this study. This is because only mathematics student teachers at one teacher education institution in central Zambia was sampled. The findings may not be generalized as being representative of the entire teacher education institutions in Zambia or beyond. Despite this the findings may be transferrable. They may not only inform teacher education programmes from where the student teachers were sampled, but also inform others which offer mathematics teacher education programmes in Zambia or be used in similar other settings and contexts. They will also help narrow the knowledge gap in the area under study.

CONCLUSION

This study reveals that student teachers predominantly hold transmission-oriented conceptions of learning mathematics. Their views align closely with passively receiving mathematical knowledge from lecturers, prioritizing memorization of facts and procedures over reasoning, sense-making, or relational understanding. Crucially, these conceptions neglect the role of construction of knowledge, self-directed learning and the development of independent problem-solving skills. This suggests an underlying belief that mathematics must be delivered by an expert rather than also constructed through active inquiry, exploration, or critical engagement. Such conceptions risk perpetuating a cycle of procedural, dominantly teacher-centered pedagogy when these student teachers enter classrooms, potentially hindering their future students' conceptual understanding and mathematical agency.

Understanding these conceptions is not merely diagnostic, but fundamental to improving teacher education effectiveness. If unaddressed, these limited conceptions may constrain student teachers' own learning during training and ultimately shape their instructional approaches, reinforcing less effective practices.

RECOMMENDATIONS

To transform these conceptions and better prepare mathematics teachers, the following evidence-informed actions are recommended: Mathematics teacher education programs should implement mandatory diagnostic assessments of student teachers' conceptions of mathematics learning at programme entry. This can help establishes a baseline for targeted intervention and tracks conceptual shifts over time. Mathematics teacher educators must model mathematics instructional practices that foster inquiry, problem-solving, and discovery, development and application of self-directed learning strategies and the value of productive struggle. Further research is recommended to track how targeted interventions within mathematics teacher education programs impact the evolution of student teachers' conceptions and, subsequently, their early-career teaching practices and student outcomes. This would help refine best practices.

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