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Learners' Perceptions and Attitudes Towards Learning of Calculus in Secondary Schools: The Case of Three Selected Secondary Schools in a District of the Northern Province of Zambia

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Abstract

This study sought to examine senior mathematics secondary school learners' perceptions and attitudes towards the learning of Calculus in a selected district of the Northern Province in Zambia. The research design was Analytical and descriptive. Therefore, quantitative and qualitative data were collected from 400 learners using a questionnaire. The Relative Importance Index (RII) guided the identification and determination of factors influencing learners' perceptions and attitudes regarding the learning of calculus. The data collected were analyzed using Statistical Package for Social Sciences (SPSS) version 20.0. It was established that the majority of learners perceived calculus to be an important subject as it encouraged them to think deeply thus improving their ability to make daily life decisions. Consequently, learners have a positive perception of calculus and an equally positive attitude towards calculus. Furthermore, it was established that apart from learner effort, parental, peer and teacher support were identified as key drivers in positively influencing students' learning of Calculus in secondary schools under the study.

Keywords: Calculus, perception, attitudes, learners, secondary school

1. Introduction

Mathematics is made up of many branches. One of the branches is Calculus. Calculus is a full course at tertiary level in Zambia, while at secondary school it is a topic embedded in the senior mathematics syllabus. The senior mathematics syllabus covers work from grade 10 to grade 12. Calculus was introduced in the senior mathematics syllabus in 2013 in order to meet some of the mathematical demands of tertiary courses (MESVTEE, 2013).

Calculus as part of mathematics is of an abstract nature and most learners find it challenging to understand its abstractness. Thus, it is important to consider learners' perceptions and attitudes towards the learning of calculus since positive

perceptions and attitudes can greatly enhance learners' morale and hence result in an improved understanding of the concepts in the topic of Calculus.

Many studies reported that mathematics attainment levels had a fundamental effect on students' attitudes (Hannula, 2002; Tapia & Marsh, 2001; Lopez et al. 1997), whereas other studies observed that students' attitudes affected attainment levels, by which an increase in positive attitudes towards mathematics might increase students' achievement levels (Higbee & Thomas, 1999). Much research relating to attitudes towards mathematics teaching and learning have been carried out over a number of decades. This study investigated learners' attitudes and perceptions towards calculus.

Calculus as a topic was introduced in the Zambian mathematics senior secondary school syllabus for the first time in 2013. Before 2013, at secondary school level Calculus was only offered to learners taking Additional Mathematics and that these were not many because few schools were offering the subject at that time (MESVTEE, 2013). It is argued that Calculus was introduced at the Zambian secondary school level in order to adequately prepare learners for science related courses tertiary level (Nachiyunde et al., 2021). In order to accommodate the topic of Calculus in the O-level Mathematics syllabus the following calculus concepts were included in the syllabus: equations of tangents and normals, differentiation of functions from first principles, differentiation rules, integration and evaluation of simple definite integrals, using integration to find area under a curve.

1.1 Statement of the Problem

Since the inclusion of Calculus in O-level mathematics syllabus, the general observation by education stakeholders in Zambia is that learners are underperforming in this topic. For instance, the Examination Council of Zambia examiner's report for 2016 revealed that some candidates in the district under study performed poorly in Calculus topics. At one of the secondary schools in the district, Grade 12 pass percentages in Mathematics four consecutive years 2016, 2017, 2018 and 2019 were 41%, 42%, 38.4%, and 42.1% respectively. It was revealed that Calculus was one of the topics that contributed to this dismal performance. Results for other schools in the district were similar to the ones outlined here. This performance is a concern to the stakeholders in the education system and the public at large in Zambia.

1.2 Purpose of the Study

The study purposed to assess learners' perceptions and attitudes towards learning of Calculus in secondary schools of three secondary schools in a district of the Northern Province of Zambia. The study further examined factors affecting students' learning of Calculus in secondary schools. Specifically, the study was guided by the following research questions:

- What are the perceptions and attitudes of Grade 12 mathematics learners towards Calculus in secondary schools?
- What are the factors affecting students' learning of the topic Calculus in secondary schools?

2. Literature Review

2.1 Teaching and Learning Calculus: A Global Perspective

To understand the teaching of Calculus, researchers in Europe used a small expert-based survey and a literature review to trace the development of Calculus teaching in schools and identify commonalities and differences as well as challenges (Bressoud et al., 2016). The learning of calculus, a branch of mathematic, differs amongst different countries and regions, influenced by cultural, historical, and educational factors.

In United States of America (USA), Calculus is and has, as asserted by Judson et al. (2005), always been considered a university-level course. However, of late Calculus has been taught in high schools. The challenge has been that Calculus has a long standing reputation of being a barrier for students desiring to proceed to the university. There has been high rate of failure in Calculus by students in the USA high schools who attempt to enter university (Judson et al.). This is similar to Japan as well, where even though the students demonstrated superior skills in algebraic compared to their American counterparts, there was no difference in their understanding of Calculus in Japan and for most of those whom Calculus is a requirement for an intended major, this same course is then redone at university (Bressoud et al., 2009). During the early 1950s, the College Board established the Advanced Placement program as a mechanism to allow high school learners who are ready for

university-level studies to do Calculus in their high schools and to be certified, through a national examination, as having completed the full equivalent of a university-level course.

2.2 Teaching and Learning of Calculus in Africa

The introduction of Calculus in other parts of the world resulted in teaching of Calculus in Africa. Currently, Calculus is being taught at high school in many countries. For instance, in Ethopia Calculus it has been taught in Grade 12 following an educational policy of 1994. Along similar lines South Africa has over the years implemented a calculus teaching improvement initiative with the aim of helping high school students prepare for higher mathematics courses in tertiary institutions (Brijlall & Ndlovu, 2013).

Zambia has also introduced the teaching of Calculus following the revision of the senior secondary school mathematics syllabus in 2013. The introduction of the topic was as a result of fulfilling a need to prepare secondary school learners for mathematics courses at tertiary level.

According to Henderson and Rodrigues (2016), poor teaching methods and teacher attitudes are the main causes of students' unfavorable views about mathematics. When teachers deliver their lessons in ways that engage learners, it is likely that learners will have positive attitudes towards their learning. In the same vein the teacher's attitude towards their learners will determine how learners respond to the teacher (Domino, 2009). According to a study by Dauda et al. (2016), mathematical proficiency, the style of instruction, and the instructional materials are all highly regarded by students as critical drivers of their academic achievement. In accordance with Dauda et al., a student's perception of a subject determines whether they succeed or fail in it. Due to the unfavorable impression left by previous generations who had negative experiences with inexperienced professors, some pupils have the misconception that mathematics is a no-go area. Etuk, Afangideh, and Uya (2013) discovered that one of the reasons students had a bad attitude toward learning mathematics and hence scored poorly in mathematics was teachers' inability to teach mathematics effectively. According to a study by Ampadu (2012), instructors' actions and inaction can have a positive or negative impact on students' attitudes about learning mathematics. The majority of students said that their teachers have a significant influence on how they feel about math. Students' attitudes toward learning calculus are influenced by their enthusiasm in the subject. However, students lack access to enough study materials to aid in their calculus development. In order to change students' attitudes about learning calculus in a positive way, it is important for teachers to start giving them more study materials.

The study's conclusions regarding the variables influencing students' perceptions and attitudes toward learning calculus reveal that parental support, student preparation attendance, and instructor support were the three variables that had the greatest influence on students' perceptions and attitudes. The findings of the study indicated that parents and teachers generally will influence how students approach the subject. The majority of the students who were interviewed said that their perception and attitude toward learning calculus could alter depending on how the teachers see the subject and comment on their progress. The attitude of the teacher will have an impact on the attitude of the students, according to Mensah et al. (2013). The learners' suggestions that teachers should employ various engaging techniques in order to make learning fun support Mji and Makgato's (2006) hypothesis that the teacher's comprehension will have an effect on the learners' attitudes. Not because their parents or guardians are not interested in their education, but rather because they lack the financial resources to provide the necessities that a learner would need in order to thrive in their studies, such as purchasing suggested study materials or textbooks for the subject, some of the students pointed out that they hardly receive support from their parents or guardians with regard to their education.

Studies conducted in South Africa by Bayaga and Wadesango (2014) acknowledge a link between attitudes toward mathematics and upbringing. The research also emphasized the importance of parents' involvement in shaping how children view mathematics. This would imply that youngsters would dislike mathematics as a result of receiving criticism from their parents for not being competent at it. As a result, calculus skills among students appear to be insufficient. Therefore, parents must be concerned about providing their children with the resources they need to succeed in calculus. However, Tahar et al. (2010) contend

that students' excitement for the topic has an impact on their attitudes about mathematics. Despite this, the poll also revealed that pupils do not have enough access to study materials to support their development in calculus. Teachers need to start providing their students with more study tools for calculus in order to positively alter their perceptions and attitudes regarding the subject. Adalikwu and Iorkpilgh (2013) on the influence of instructional materials in teaching and learning of mathematics, found that students taught with instructional materials had strong positive perception and attitude towards mathematics and hence performed significantly better than those who were taught without instructional materials and were characterized by having weak negative perception and attitude towards mathematics, which eventually made them perform poorly in mathematics.

3. Methodology

The following methods and procedures were adopted to conduct this study.

3.1 Research Design

The study adopted descriptive survey research design that allowed the researcher to utilize qualitative and quantitative methods of data collection and analyses. Analytical and descriptive research design enabled the researcher to collect information or data by administering a questionnaire to grade 12 learners. This design was chosen to make references to phenomena as they exist in real life, and it is relatively economical in terms of time and resources.

3.2 Population and Sample

The population of the study comprised all the grade 12 learners in all secondary schools of a district in the Northern province of Zambia. The said district has a population of six (6) secondary schools, with 486 Grade 12 learners. The study population then comprised six (6) secondary schools, and 486 Grade 12 learners from the six (6) schools in the district. The district was purposively selected using as a study site because it has secondary schools that offer mathematics.

3.3 Research Instruments

The study used a questionnaire as an instrument for collecting data from the respondents. The questionnaire had questions which addressed the research questions. It was used to collect data on the perceptions and attitudes held by the participants towards the learning of Calculus. Furthermore, the questionnaire collected data on the factors that affected learners' perceptions and attitudes. The questionnaires were measured on a five-point Likert rating scale, with Strongly Agree (SA) equaling one, Agree (A) equaling two, Neutral (N) equaling three, Disagree (D) equaling four, and Strongly Disagree (SD) equaling five. This study tool was created to facilitate the effective application of statistics in data interpretation. The Relative Importance Index (RII) was used to establish a relationship between perceptions and attitudes of learners towards learning calculus.

3.4 Validation of Research Instruments

To ensure validity, research instruments were given to the supervisor and other research experts to reveal and sort out ambiguities. Validity of research instruments was enhanced further through expert judgment such as colleagues that have done research before and other academicians. The meaning of every term in the interview schedule will be clearly defined to have the same meaning to all respondents. Reliability concerns was addressed or countered by ensuring that respondents gave consistent responses. Table 1 show the factor loading with all Cronbach's alpha values greater than the minimum threshold of 0.7 (Pallant, 2016).

3.5 Data Analysis Procedures

The analysis of data was guided by the research objectives and hypothesis. To do this, the researcher classified and coded the data. Analysis of data was made possible by using a software package called SPSS version 20.0 (IBM) for generating descriptive statistical data tables.

4. Results and Findings

The findings of the study revealed that the majority of the learner respondents believe that their teacher can help them do better in calculus. This observation is reflected in the statement "I believe that my teacher can do better to help me pass calculus" which ranked highest among the 9 listed statements. It was further observed that in terms of gender, boys perform better in calculus than girls as evidenced by the ranking of the statement "boys perform better in calculus than girls" which ranked 7. Using the Relative Importance Index, factors influencing learners' perceptions and attitude with regards to learning calculus were established. The findings revealed that most learners view calculus as an

important subject that encourages them to think more deeply consequently improves their ability to make decisions in daily life. It is thus concluded that learners have positive attitudes towards calculus. These findings are consistent with what has been observed as regards learners' perceptions and behave in similar other studies.

4.1 Perceptions and Attitudes of Learners' Towards Learning of Calculus

The perceptions and attitudes questionnaire was administered to the learners in order to assess learners' perceptions and attitudes towards learning calculus. The results of analyzing the learners' perceptions and attitudes towards learning calculus are shown in Table 1.

Table 1. Perceptions and attitudes of learners towards learning calculus (n=271)

Statement	Relative Importance Index	Rank
I feel calculus is an important subject	0.8030	1
Calculus is a useful subject that will always be used in daily life	0.7469	4
Calculus offers me opportunities for career development	0.7292	5
Calculus is a tool for developing our ability to think	0.7934	2
I will need calculus for my future work	0.7240	7
I often wish I was not taking calculus	0.4804	11
Calculus involves the study of concepts such as differentiation, integration, algebra etc.	0.7875	3
Calculus will not be important to me in my life's work	0.4317	12
Calculus is difficult due to teachers' teaching methods	0.5454	10
Calculus is easy due to teachers' teaching methods	0.7255	6
I enjoy calculus because it has helped me to perform better in other subjects	0.7196	8
Performance in calculus for most learners is very poor	0.5793	9

Table 1 reveal that from the ranking of the statements relating to the perceptions and attitudes of learners towards learning calculus, "*I feel calculus is an important subject*" was the most highly ranked statement followed by the statement "calculus is a tool for developing our ability to think". This is a clear indication that the majority of the learner respondents considers calculus to be an important subject that fosters them to think deeper and hence improves their decision making in everyday life. This is further compounded by seeing that very few learners considered calculus not to be important in their lives. This is why the statement "*calculus will not be important in my life's work*" was ranked the least. While learners appreciate that calculus is important, there is a need to get learners to start enjoying calculus in order to have them perform better in other subjects. Apparently, as revealed from the survey, the majority of the learners do not seem to enjoy calculus which is why the statement "*I enjoy calculus because it helped me to perform better in other subjects*" is ranked number eight, that is one of the lowest rankings in the list.

4.2 Factors that Influence Learners' Perceptions and Attitudes in Learning Calculus

The factors questionnaire was administered to the learners in order to establish which factors contribute towards learners' perceptions and attitudes when learning calculus. The results of analyzing the learners' factors influencing learners' perceptions and attitudes in learning calculus are shown in Table 2.

Table 2. Factors that influence learners' perceptions and attitudes in learning calculus

Statement	Relative Importance Index	Rank
My teacher gives me enough support when teaching calculus	0.7823	3
My classmates support me in solving calculus	0.7579	5
My parents gives me support to go school	0.8701	1
I attend prep	0.8465	2
My teacher explains fully when teaching calculus	0.7727	4
My teacher involves learners when he/she is teaching calculus	0.7454	6
My teacher use a textbook when teaching calculus	0.5661	7
I have enough study materials for calculus	0.5292	9
My social economic background affect my performance in calculus	0.5572	8

Table 2 exhibits factors that influence learners' perceptions and attitudes in learning calculus. The outcome of the study reveals that parents support, attending prep by the learners, and teachers support to learners were the most highly ranked factors that were paramount on influencing learners' perceptions and attitudes in learning calculus. As can be viewed from Table 2, it is evident that the statements "My parent gives me support to go to school" is ranked number 1, "I attend prep" is ranked number 2, and "My teacher gives me enough support when teaching calculus" is ranked number 3. However, the statement "I have enough study materials for calculus" gives undesirable results since it is ranked the least. This implies that learners do not have enough study materials that they could use to help them improve in calculus. It is thus significant for the teachers to begin providing more study materials on calculus to learners, so as to develop learners' perceptions and attitudes towards the learning of calculus in the positive sense.

5. Discussion, Conclusion and Recommendations

5.1 Discussion and Conclusion

5.1.1 Perceptions and Attitudes of Learners Towards Learning of Calculus in Secondary Schools

Numerous conclusions were drawn from the observations in the results and findings section. The research's most significant finding is the discovery of learners' attitudes and views regarding learning calculus. Although the literature study cited several research papers that pinpointed the factors influencing students' perceptions and attitudes toward mathematics, none of them specifically addressed the teaching of calculus in Zambian secondary schools.

Based on the findings from chapter four, Table 2 shows that most learner respondents view calculus as an important subject that encourages them to think more deeply and, as a result, improves their ability to make decisions in daily life. As a result, learners have a positive attitude toward calculus. Additionally, perceptions and attitudes guide how we see things and how we should respond to them (Tsanwani et al., 2014). This is made worse by the fact that very few students believed calculus was unimportant to their lives. Evidence suggests that students' views of mathematics are important in the sense of accomplishment and competence they develop, according to Fullarton et al. (2003). The research findings from this study are somewhat consistent with how learners perceive and behave when learning calculus, according to other academics. For example, Nachiyunde et al. (2021) make the claim that some students think they will require mathematics in the future. However, Tabao and Alaizah (2020) object that while mathematics may be a part of daily life, that does not necessarily imply that it is crucial to everyone's success in life. Overall, perception and attitude toward mathematics play a key part in the teaching and learning process of mathematics as it determines students' accomplishment in mathematics, according to Farooq and Shah's (2008) argument.

5.1.2 Factors that Influence Learners' Perceptions and Attitudes in Learning Calculus

Table 2 lists the variables that affect how calculus students perceive and feel about the subject. The study's findings show that parental support, student preparation, attendance, and instructor support were the three elements that had the most impact on students' perceptions and attitudes toward learning calculus. But Tahar et al. (2010) assert that students' attitudes toward mathematics are influenced by their enthusiasm in the subject. Despite this, the survey also discovered that students lack access to enough study materials to aid in their calculus development. In order to change students' thoughts and attitudes about learning calculus in a positive way, it is important for teachers to start giving them more study materials on the subject.

5.2 Research Contribution

Not much has been documented on teaching and learning Calculus in Zambian secondary schools. This means more and more studies are needed to generate information that could be used to improve quality of education with specific reference to Mathematics. Policy formulation for education programme could be well informed. In a nutshell, this study is very relevant to inform educational policy implementers such as Provincial Education Officers (PEO), District Education Board Secretaries (DEBS), Senior Education Standards Officers (SESOs), Headteachers and the teachers on the perceptions and attitudes that teachers and learners hold regarding Calculus. Furthermore, the study results could help these key stakeholders to change certain perceptions and attitudes by addressing teachers' and learners cognitive, affective, and emotional needs.

Approaches to perceptual and attitudinal transformation in Mathematics could be developed by taking into consideration commitment and effort. Policy makers and implementers could as well have an understanding that attitudes of both teachers and learners are influenced by myriad factors such as family, religion and culture which affect the behaviour and ultimately impact the education system and its outcomes. This study could give teachers insight into specific factors to be considered while planning their lessons to improve their teaching strategies and boost quality Mathematics education.

The study is a significant contribution to our understanding of how secondary school teachers and students perceive and approach the teaching and learning of calculus. The theoretical contribution and the practical contribution are the two subsections that make up this section that explains the research contribution.

Calculus is a branch of mathematics that can be challenging for secondary school learners. Nevertheless, learners' perception can differ significantly. Some learners may perceive calculus as an important subject for future careers in STEM fields, while others may see it as a difficult and abstract subject. Attitudes towards calculus can also be influenced by prior experiences with mathematics and teaching styles. Overall, it is important for teachers to create a positive learning environment and approach the subject in a way that makes it accessible and engaging for all learners.

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