

**Article**

## **An Investigation into the Strategies Used to Teach Geometric Constructions in Secondary Schools: A Case of a Secondary School in Lusaka District**

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### **Abstract**

This paper endeavors to investigate the strategies used by secondary school teachers in the teaching of Geometric Constructions. A qualitative method was used to obtain data and richer information about the topic. The study involved three grade twelve teachers of mathematics at a selected secondary school in Lusaka district. Lesson observations were done four times with each teacher, interviews and focused group discussions were also conducted. The study revealed that teachers used learner-centered approaches of teaching which included demonstration, discussion, problem solving, question and answer, inquiry and teacher exposition methods. However, their performance in class was affected due to lack of resources. The study also identified other strategies which could improve learner performance through learner participation. Based on the findings it was recommended that Continuous Professional Development (CPD) on Geometric Construction for teachers should be conducted in order to enhance the in-depth knowledge on the topic to enable the teachers to teach with confidence. Furthermore, the school needs to acquire teaching aids/resources in Geometric Construction to enhance effective teaching because the topic cannot be taught without the required instruments.

**Key words:** Geometric Construction, Teaching, Learning, Performance.

### **1. Introduction**

Mathematics is an important subject in the Zambian School Curriculum. In the national policy document, *Educating Our Future*, it is stated that upon completion of grade 9, every pupil should have attained sustainable level of competence in numeracy and the skills of using mathematical concepts and processes in matters of everyday life (Ministry of Education [MoE], 1996). The importance of mathematics in the curriculum is reinforced further in the *Zambia Education Curriculum Framework 2013* in which it is stated that mathematics is one of the key learning areas in the education system in Zambia. This is because numeracy and mathematical skills promotes positive behavior that enables individuals to deal with the demands and challenges of

everyday life (Ministry of Education, Science, Vocational Training and Early Education [MESVTEE], 2013a). Many other facts and statements illustrate the importance of mathematics in the Zambian school curriculum. Looking at the Ministry of General Education's structures of the school curriculum at various levels of school, mathematics is the only subject that is compulsory all the way from Grade 1 to Grade 12. Additionally, mathematics is allocated one of the highest numbers of teaching and learning periods at each of the levels (MESVTEE, 2013a). As from the year 2000, an O'level grade, that is 1 to 6, is a requirement for admission to all primary colleges of education. There is a general agreement that every child should study mathematics as it is regarded by most people as essential (Cockroft, 1982). Despite the perceived usefulness of mathematics, there have been repeated failure by many learners in Zambia (Nkhata, 1996). Odili (1986) observed that mathematics is one of the most poorly taught, widely hated and abysmally understood subject in secondary school. Students particularly girls avoid the subject. Nkhata (1996) wrote that in Zambia the failure rate for girls cannot be called very poor but 'scandalous'. According to MOE (1996) the overall unsatisfactory performance in School Certificate Examinations is attributable in large measure to poor performance in mathematics and science. Such concerns are a clear indication that interventions in the teaching of mathematics must be designed to mitigate the learning problems faced by pupils especially in areas such as Geometry and Geometric Constructions in particular. Therefore, this study focused on identifying the strategies used to teach Geometric Construction in secondary schools. It is proposed that exposing these strategies will call for interventions that will eventually lead to improved quality of learning mathematics and its applications in real-life.

## **2. Statement of the Problem**

Construction has already been established as a vital part of the mathematics curriculum in Zambia. However, in the national examinations learners have performed poorly in the topic. The Chief examiners' annual reports in mathematics in the School Certificate and General Certificate of Education (GCE) conducted by the Examinations Council of Zambia are good testimonies of these facts. Learning constructions may not be easy, and a number of students fail to develop an adequate understanding of constructions concepts, constructions reasoning and constructions problem solving skills (Elchuck, 1992). A number of factors could be contributing to making the learning of geometric constructions difficult. Generally, one of the key factors in pupils' learning achievement is the quality of teaching (Trust, 2011). The case for Zambia is that there are persistent reports of learners either shunning examination questions on geometric constructions or making poor attempts at the questions, but hardly any information regarding the teaching and learning of the topic, hence the study.

## **3. Literature Review**

Literature on the past research point out that most of the basic knowledge and skills on geometric constructions help students to discover and explore geometric relationships and interpret geometric concepts and theorems (Jones, 2002). Students should be encouraged to use descriptions, demonstrations and justifications in order to develop the reasoning skills and confidence needed to underpin the development of an ability to follow and construct shapes geometrically (Goos M, Stillman G & Vale C, 2007). The most obvious expectation related to geometric constructions is that students should be able to draw and construct representations of

two- and three-dimensional geometric objects using a variety of tools (Lamphier, 2004). Ozerem (2012) stated that studying geometry is an important component of learning mathematics because it allows students to be equipped with the tools they can apply in other areas of mathematics. Exploratory geometric constructions help to develop understanding of formal geometric concepts only if students grasp the connections between straightedge and compass procedures and their formal geometric analogs (Lamphier, 2004). Geometry offers us a way to interpret and reflect on our physical environment and can serve as a tool for understanding other topics in mathematics and science but receives no attention in instruction (Lappan, 1999). When planning approaches to teaching and learning geometry, it is important to ensure that the provision in the early years of secondary school encourages students to develop an enthusiasm for the subject by providing opportunities to investigate spatial ideas and solve real-life problems (Jones, 2002). Noraini (1999) insisted that construction geometry needed more real-life situation and hands-on activities to enhance geometric thinking skills. It is therefore more important that geometry instructions incorporate new and tested approaches such as using visual and multimedia tools in the classroom. Ozerem (2012) states that when construction activities are used, they involve developing new ideas and connecting these with students' existing ones. According to Cangelosi (1996) instruction should provide opportunities for students to actively use mathematical language to communicate about and negotiate meaning for mathematical situations. Jones (2002) observed and suggested that to teach geometry effectively to students of any age or ability, it is important to ensure that students understand the concepts they are learning and the steps that are involved in particular processes rather than the students solely learning rules. Van Hiele (1999) who states that optimal geometry learning is achieved when students have developed their critical thinking. Previous researchers have shown that improving teaching as well as the geometric understanding of learners can be done by organizing instruction in such a way that it would take learners' thinking ability into account whilst the new work is being introduced.

#### **4. Methodology and Procedures**

##### **4.1. Research Design**

The study used the qualitative methodology. The basic qualitative design was used for the participants to give richer answers to questions and valuable insights (Cresswell, 2012). Consequently, data collection was done through observations, interviews and document analysis to provide descriptive accounts targeted at understanding of strategies used in the teaching of Geometric Constructions (Cresswell, 2003). The experience of the participants when they taught the topic was the main purpose for the study.

##### **4.2. Study Area or Site**

The School at which this study was conducted is a secondary school located in Lusaka Central Zone. It is a government school which was initially built as a primary school and later on upgraded to a secondary school in 2013. At the time of the study, the school had twenty-two classrooms and offered both morning and afternoon classes. It had a population of over four thousand pupils (girls and boys) from grade eight to twelve. It had a total of sixty-six members of staff of which twenty were male and forty-six were female. The mathematics department had

a total of eight teachers of mathematics and three teachers of computer studies. Of the eight teachers of mathematics three were male and five were female.

#### **4.3. Study Population and Sample**

The population of the study comprised all the teachers of Mathematics at the selected Secondary School in Lusaka District. The sample consisted of three Mathematics teachers from one secondary school who were purposively sampled. These were the only teachers who were teaching the grade twelve classes and they were all looking at Geometric Constructions in their usual classes. The classes were selected according to what could fit well on the Time Table of the researcher without so much crushing as each teacher had more than one class. Mathematics was scheduled for the morning periods for the whole school on the Time Table. Hence the classes which were scheduled for the same time had to be re-scheduled for the researcher to meet them at different times. Each teacher was observed in one class of about sixty grade twelve pupils. This sample was representative enough since all the teachers handling grade twelve classes were part of the study. The study needed a relatively small sample size in that it required the use of triangulation in data collection instruments. The data collected from the observations was compared with that of the interviews and the document analysis.

#### **4.4. Characteristics of the Sample**

The study involved three teacher participants. To maintain confidentiality, as required by research ethics, the three participants were identified as Teacher 'A', Teacher 'B', and Teacher 'C'. All the three participants were male aged above thirty-five years. The highest qualification for each one of the three was a Secondary Teachers Diploma in Education. In Zambia, a Secondary Teachers Diploma qualifies one to teach at the junior secondary school level only. However, due to a shortage of appropriately trained teachers of Mathematics, it is common to have teachers holding Diplomas teaching at the senior secondary school level as well. Teacher 'A' and 'B' had only taught mathematics for four years in upper secondary as they taught in basic schools for the other years. Teacher 'C' had taught Mathematics in high school for over eleven years.

#### **4.5. Sampling Procedure**

This study used the purposive sampling procedure. According to Cohen (2007), purposive sampling suggests, the sample which has been chosen for a specific purpose. In qualitative research, researchers handpick the cases to be included in the sample on the basis of their judgement of their typicality or possession of the particular characteristics being sought. In this way, they build up a sample that is satisfactory to their specific needs. Therefore, purposive sampling was used to choose teachers who had grade twelve classes and those who were teaching Geometric Construction.

#### **4.6. Data Collection Instruments**

To collect qualitative data for the study, the researcher used lesson observations, interviews with the teacher participants, Focus Group Discussions with pupils, and analysis of documents related to the teaching of Mathematics in the school. Lesson observations: This was the main instrument which was used to collect data. The instrument was adopted from one of the lesson

observation instruments designed by the Ministry of Education to enhance School-Based Continuous Professional Development through lesson study. A few modifications were made to the instrument to suit the study. Internal validity was taken care of through audit-trail and chain of evidence. This was done through giving comments on what was observed. Its main focus was to examine the lesson objectives, teaching methods, activities used, teaching and learning materials and teaching strategies. The research process was designed according to a clear methodological tradition so as to build up a complex, holistic framework by analysing narratives and observations, conducting the research work (Cresswell, 2007). Observations of teachers' instructional practices provide firsthand accounts of what teachers and students do in classrooms in the process of teaching and learning Mathematics (Boston, 2012). According to Kothari (2004), the main advantage of this method is that subjective bias is eliminated, if observation is done accurately. Secondly, the information obtained under this method relates to what is currently happening; it is not complicated by either the past behaviour or future intentions or attitudes. Thirdly, this method is independent of respondents' willingness to respond and as such it is relatively less demanding of active cooperation on the part of respondents. Twelve observations were conducted with three different teachers accompanied by field notes and video transcripts. Each teacher was observed four times and the main focus was on the teaching strategies and the involvement of pupils during the lessons. The classroom activities, examples and exercises were analysed as a way of checking learners' understanding and participation. Interviews: The questions in the interview schedule focused on the teaching strategies of Geometric Construction and the challenges teachers faced in teaching the topic. Open ended questions were mostly used to gather as much information as possible. The researcher designed the interview schedule for the teacher participants. Post lesson interviews were conducted with teachers after each observed session. Teachers were asked about their thoughts, first while they were preparing the lesson about what they wanted pupils to learn and then afterwards asked them how well pupils learned. Then at the end, teachers were asked about the pitfalls that they had experienced and also had to seek clarification over observed lesson. The main interview was done before all the observations started.

Document Analysis: According to Hammond & Wellington, (2013), document analysis are the strategies and procedures for analysing and interpreting related materials relevant to a particular enquiry. Documents such as schemes of work, lesson plans and records or work were collected and analysed as they reviewed what was done or what was expected to be done and how it could be done. This was to check the past record of how the topic was taught and the strategies which teachers used to teach the topic in the previous year. Focus Group Discussion (FGD) with Pupils: FGDs are unnatural settings yet they are very focused on a particular issue and therefore, yield insights that might not otherwise have been available in a straight forward interview (Cohen , Manion and Morrison, 2007). The participants interact with each other rather than with the interviewer, such that the views of the participants can emerge. After each observed lesson, pupils were interviewed to find out their strength and weaknesses during the lesson. All the discussions were audio taped.

#### 4.7. Procedures for Data Collection

Interview guides were used to obtain information from teachers before and after the lessons were taught. The post lesson interviews were unstructured as the questions were dependent on the lessons. While observation guides were used to collect data from the classroom observations which were conducted on the teaching and learning styles of Geometric Constructions. This was done to confirm the ideas raised by the participants during the interviews. The data collection process was carried out after the instruments were piloted to check for clarity, meaningfulness and gaps in the questions. The actual data collection was conducted in the third term of 2015 academic year from August to September. To gain access to the participants, the researcher reported to the Headteacher who gave permission to observe and interview the participants.

#### 4.8. Data Analysis

The data that was obtained from interviews, FGD's and the lesson observations was analysed according to themes. Firstly, by a process of coding meaningful units in the transcripts and the notes. For interviews and FGD, the initial process was to transcribe the audio recordings. For lesson observations, video recordings were also transcribed. Both the transcripts and the observation notes went through two rounds of coding because of the need to focus on the different research objectives in each round of coding. The first round focused on the various pedagogical methods that the teacher used in the three lessons. The rationale for this initial analysis was that teacher's actions in response to teaching tasks places teachers' knowledge in action could be identified. The main codes categorised the themes 'teaching strategies'. These teaching strategies were recorded according to the teacher's introduction, lesson development and the lesson evaluation. The second round of coding was based on the second research question which looked at the challenges faced when teaching Geometric Construction. The codes were categorised and compiled according to what was common or what distinguished them. The process of categorising the codes formed the basis for generating themes. Themes encompassed wider issues of teaching such as resources, follow-ups, questioning techniques, language, and teacher preparedness. Afterwards, the researcher combed through all the transcripts and notes searching for other evidence and indications of the mathematical knowledge.

### 5. Findings and Discussions

#### 5.1. Strategies used to teach Geometric Constructions in Secondary Schools.

The following were the codes, categories and theme generated for the strategies used to teach Geometric Constructions.

Table 1: *Strategies to enhance Learning in Geometric Construction*

Codes	Category	Theme
<ul style="list-style-type: none"> <li>• Arousing interest of learners</li> <li>• Using learner centred methods of teaching</li> <li>• Giving exercises, home works and assignments</li> <li>• Monitoring of pupils</li> <li>• Making follow ups</li> </ul>	Instruction to support the teaching-learning path	Strategies to enhance Learning in Geometric Construction

Codes	Category	Theme
<ul style="list-style-type: none"> <li>• Considering individual differences</li> </ul>		
<ul style="list-style-type: none"> <li>• Discussing</li> <li>• Demonstrating</li> <li>• Inquiring</li> <li>• Teacher Exposing</li> <li>• Problem Solving</li> <li>• Working in Groups</li> </ul>	Teaching methods	
<ul style="list-style-type: none"> <li>• Motivating learners</li> <li>• Having exchange programmes</li> <li>• Willingness to learn</li> <li>• Studying Habits</li> <li>• Using real life situations</li> <li>• Defining new terms</li> </ul>	Improving learner performance	
<ul style="list-style-type: none"> <li>• Constructing</li> <li>• Practicing</li> <li>• Participating</li> </ul>	Learner Participation	

## 5.2. Instruction to Support the Teaching-Learning Path

**Arousing interest of learners:** During observations the teachers introduced their lessons in a way of capturing the pupils attention. This helped the teachers to make the pupils attentive and interested in the lesson. For example, in one of the introductions for teacher ‘B’s lessons, he stated that the geometrical instruments needed were found in the mathematical set. The teacher got a mathematical set from one of the pupils to show the learners the instruments needed for construction which were a divider, a pair of compasses which was not moving, a protractor and a ruler. Teacher ‘A’ was also observed arousing the learners interests during the lesson introduction by asking them questions. This helped the teacher to attract the attention of the learners as the class had too much noise when the teacher walked in. The teacher managed to control the noise through questioning. As the learners answered the questions the noise minimised and eventually everyone was quiet so as to get what was going to be learnt in the days’ lesson. And finally, the teacher connected to the lesson he was to teach with relevant previous knowledge.

**Using learner-centered methods of teaching:** During interviews, the teachers mentioned that they used learner-centered methods to teach the topic Geometric Construction to help the learners understand the topic fully. The lesson introductions discussed above had shown pupils getting involved in the lessons, contributing and reflecting on what was learnt in the previous lesson. The teachers used question and answer method in the introduction of lessons as one of the approaches in learner-centered methods of teaching.

**Giving exercises, home works and assignments:** During interviews, the teachers mentioned giving exercises, homeworks and assignments to learners to help them in monitoring the activities and performance of the pupils. This was also observed during the lesson observations. Exercises, homeworks and assignments were given to the pupils. All the three teachers gave some exercises, homeworks and assignments.

**Monitoring of pupils:** During interviews, Teacher ‘A’ explained that he monitored the pupils by constructing together and by going around at the same time. Whereas Teacher ‘B’ monitored the pupils through the exercises and the homeworks he gave the pupils to do. Teacher ‘C’ mentioned during interviews that he monitored the pupils through assessments and exercises he gave which had more than two components of constructions combined. This was evident during lesson observations that exercises and homeworks were done by Teacher ‘C’.

**Making follow – ups:** During interviews, Teacher ‘A’ and ‘B’ mentioned that they made instructional follow-ups to the pupils to make sure that they were well informed. This was seen in some instances during the class observation but more of it was seen in Teacher ‘C’s lessons when he gave exercises. He went around the class to give individual instructions to the learners who had doubts on what to do. Teacher ‘A’ also gave more follow-ups during his free time to the learners.

**Considering individual Differences:** Teacher ‘C’ mentioned during interviews that it was very difficult to meet all the learners needs due to their large numbers in classes, but Teacher ‘A’ mentioned that he tried his level best to reach out to everyone in class despite the large numbers. Whereas Teacher B explained that he depended on the board demonstrations for everyone as it was difficult to attend to everyone’s needs. Therefore, this code came up as it was a useful strategy when it came to the teaching of Geometric Constructions.

### 5.3. Teaching Methods

Teaching methods was the second category for the theme of strategies to enhance learning in Geometric Constructions. The following were the codes which formed up this category.

**Discussing:** During interviews Teacher ‘A’ mentioned discussion as a main method he used to teach the Geometric Constructions topic. He stated that it was one of the methods recommended as a learner-centered method to keep all the learners actively involved during the lesson. Teacher ‘B’ mentioned it as well that it was one of the methods he used to teach the topic and Teacher ‘C’ mentioned it too. The method was less applied during the observations made but it came out especially in Teacher ‘C’s class as the pupils moved to their peers who understood better to ask for help. It was also in Teacher ‘A’s class were the pupils discussed according to the way they sat in twos and threes. This helped the learners to acquire some knowledge from peers.

**Demonstrating:** During lesson observations, all the teachers used the demonstration method during their lesson developments. Teacher ‘A’ and Teacher ‘C’ mentioned using the method when teaching Geometric Construction. This code emerged as it was one of the methods which were mainly used to teach the topic. This method was seen in the lesson development for all the lessons observed from all the three teachers. The lesson development concentrated on the sequence of instruction, the use of practical activities, relevance and quality of examples, the pace of lesson, knowledge of the subject matter, level and clarity of speech and variation of class.

**Teacher Exposition:** All the teachers combined the demonstration method with the expository method as they explained how to go about constructing. Teacher ‘B’ and ‘C’ also mentioned



that they used the method in their teaching of the topic as it was conducive for large classes and the topic when constructing, as they also explained the new concepts.

**Inquiring:** The inquiry method was mentioned by Teacher ‘B’ during interviews as one of the methods he used to teach the construction topic even though it was rarely seen during class observations. Teacher ‘A’ did some inquiry though not much was observed in his lessons as he used more of teacher exposition.

**Problem solving:** Problem solving was one of the methods which was observed in Teacher C’s lessons. His exercises emphasized problem solving, thinking and reasoning.

**Working in Groups:** During interviews Teacher ‘A’ and ‘C’ mentioned that they were using groups to teach the Geometric Constructions topic. It was explained that it was one way of helping the learners to learn the concepts well. Even though during observations the researcher did not see the teachers grouping the learners, the learners in teacher ‘C’s class grouped themselves during class exercises to seek for help from fellow classmates.

#### 5.4 Improving Learner Performance Category

The third category for the theme the teaching and learning of Geometric Construction was improving learner performance. The codes came up as the teachers gave their suggestions on how best the performance of learners could be improved during interviews. The learners also gave suggestions on ways in which they could improve their performance during Focus Group Discussions.

**Motivating Learners:** It was mentioned by Teacher ‘B’ that he motivated the learners as they answered questions in class and also depending on their performance in exercises. Teacher ‘A’ said that the learners were motivated when he made sure that all of them came with their own instruments for constructing and made the lessons interesting. Whereas Teacher ‘C’ stated that the learners became motivated when they managed to construct accordingly. He further said that: *“you emphasise to them that this topic does not miss in an examination it is always there and you must know how to answer it as it is compulsory. Another motivation is that you tell them that those who will do courses which deals with construction of houses, carpentry will benefit from the topic. Another motivation is that it is a pre-requisite topic for transformation which was the next lesson.”*

**Having Exchange Programmes:** During interviews, Teacher ‘C’ said that having exchange programmes could also be done with colleges offering courses related to this topic and people who had done courses which required construction could come on board and educate the pupils on its importance. He further stated that this would help the learners improve on the performance on the topic.

**Willingness to learn:** The learners should be encouraged to learn. Willingness to learn could help them to perform better and to work hard in the topic. Teacher ‘A’ said it was difficult to keep all the learners within the lesson as some easily lost interest while learning and started doing their own things. It was observed that even the fast learners in teacher ‘A’s class were

seen doing their own things as they already knew the concepts the teacher was teaching. The topic was taught almost during examinations, when other pupils had already studied it on their own. Hence it was very difficult to sustain their willingness to learn.

**Studying Habits:** During the FGD's, the pupils said that it was difficult for them to study accordingly due to many subjects and many topics in Mathematics. They stated that there was just too much to study, hence they picked on topics which were easy to study in mathematics. They stated that constructions had only procedures without notes to read. Once something was forgotten then they could not proceed with a question. They further stated that it was difficult even to follow already done work in the exercise books if one did not practice more often.

**Using Real-Life Situations:** During interviews, all the three teachers said that they used real-life situations to connect the concepts which were newly introduced in class. During observations Teacher 'A' gave an example of three villages in a triangular place, given the distance from one village to the other and asking the learners to come up with a triangle representing the three villages. Teacher 'B' gave an example of opening the door and the turns one makes when walking. Whereas Teacher 'C' gave an example of allocation of points when one is given a piece of land. Real life situation examples helped the learners to connect the concepts with the real world to make learning meaningful.

**Defining new terms:** Teacher 'A' defined new terms through practical representation. This helped the learners to understand what he taught well. Teacher 'C' said that he defined the terms to the learners and explained what they meant before using them in teaching. Teacher B said that the new terms were demonstrated on the board of what they meant. He gave an example of inscribing and circumscribing. This was exactly what was seen as he presented his lessons during lesson observations.

#### **5.4. Learner Participation**

The final category for the theme strategies used to enhance the learning of Geometric Construction was learners' active involvement. This came about because Geometric Constructions is a practical topic, hence the codes constructing, practicing and participating emerged from both interviews and observations.

**Constructing:** During observations pupils were seen constructing with or without tools. Those with tools gave time to others who did not have to take part in practicing the work. It was not easy for most pupils to do it well, hence with more practice it became better. Other pupils used pieces of papers (to represent pair of compasses) to copy constructions from the board.

**Practicing:** Geometric Construction is a practical topic which requires hands on activities. Therefore, learners were seen practicing with the guidance of the teachers. The use of demonstration method by the teachers allowed the learners to observe appropriately as observations helped the learners to use their sense of sight and just pay attention to the procedure.

**Participating:** The pupils took part in the lessons by answering questions and asking questions. During interviews Teacher 'B' said that some learners participated fully as they were always eager to learn while others showed no interest at all. Teacher 'A' said pupil participation was

always high with constant motivation. He further said that the beginning was always crucial for the learners. While Teacher ‘C’ said that pupil participation was average in the topic.

### 5.5. Challenges Faced when Teaching Geometric Construction

The second theme resulting from data analysis was the ‘challenges faced when teaching Geometric Construction’. Categories relating to the theme included: (1) difficulties of learning constructions in classrooms; (2) difficulties in teaching constructions; and (3) class management. The codes emerged from interviews and observations on participants. Table 2 provides the codes and categories related to the second theme.

Table 2: *Challenges faced when teaching Geometric Construction*

<b>Codes</b>	<b>Categories</b>	<b>Theme</b>
<ul style="list-style-type: none"> <li>• Poor learning attitude from pupils</li> <li>• Poor foundation from primary school learning</li> <li>• Pupils lacking pre-requisite knowledge on topic</li> <li>• Pupils lacking learning materials</li> <li>• Understanding of construction language</li> <li>• Bridging of the gap of primary and secondary content</li> </ul>	Difficulties in learning Geometric Constructions in classrooms	Challenges faced when teaching Geometric Construction
<ul style="list-style-type: none"> <li>• Teachers lacking preparation of lessons</li> <li>• Using teaching materials in classrooms</li> <li>• Teachers lacking teaching materials</li> <li>• Teachers lacking support from administrators</li> <li>• Shunning to teach the topic</li> <li>• Difficulty in achieving intended objectives</li> <li>• Lacking support from parents during homework</li> <li>• Parents providing learning materials</li> <li>• Teaching large classes</li> <li>• Pupils working hard</li> </ul>	Difficulties in teaching constructions	
<ul style="list-style-type: none"> <li>• Learning environment</li> <li>• Pupils losing interest</li> <li>• Controlling of classes</li> <li>• Questioning techniques</li> <li>• Summarizing of main points</li> <li>• Evidence of learning</li> </ul>	Class management	

### 5.6. Difficulties in Learning Constructions in Classrooms

The study showed that the learners had a lot of challenges in the learning of Geometric Constructions in classrooms. The codes were discussed as follows;

**Poor Learning Attitude among Pupils:** During interviews Teacher ‘A’ said that the main challenge of teaching Mathematics was the poor learning attitude among pupils. Pupils generally lacked interest in the subject. Therefore, the teacher had to put in more to stimulate their interest. Teacher ‘A’ said that the pupils’ attitude towards the subject made it difficult for him to teach effectively. While teacher ‘C’ said about fifty percent of learners in the class lacked interest in the subject making their attitude towards learning poor. This was also observed by the researcher during lesson observations that in all the classes there were pupils who had no interest at all in what the teacher was teaching even if the examinations were approaching. Some pupils wrote nothing in Teacher ‘A’ and Teacher ‘B’s classes. Some of the pupils in teacher ‘A’s class did not even bother to remove their Mathematics books from their bags.

**Poor Foundation from Primary School Learning:** The teachers expressed their concern over the poor background of the learners in the subject. They stated that in primary school, the Mathematics taught to the learners was not properly done. Hence making it difficult for the learners to catch-up in secondary school. Teacher ‘C’ said that the poor foundation in Mathematics made the pupils learning effectively to close up. He further said that it was difficult to achieve the desired objectives in almost all the topics in Mathematics due to the nature of the learners. Building up of concepts was difficult without proper pre-requisite knowledge.

**Pupils Lacking Pre-requisite Knowledge on Topic:** Teacher ‘C’ said that the Construction topic had no connection with the primary school Mathematics. Therefore, pupils had to learn the Pre-requisites in secondary school. He narrated also that it became worse when pupils were not taught the topic at grade nine level, then they had to be taught how to hold a compass in grade twelve. He further stated that some teachers shunned teaching the topic at grade nine because it appeared in paper 2 during examinations were the pupils were free to choose other topics to answer. He said this during one of the post lesson interviews. This was also observed in teacher ‘B’s introduction lesson for the topic. Some pupils expressed ignorance of having known anything about the topic from grade nine. The records of work at grade nine level also showed that the topic was not taught to the learner for teachers two years ago.

**Pupils Lacking Learning Materials:** It was observed that some pupils lacked learning materials for the topic Geometric Construction. Pupils were supposed to have a Ruler, Pair of Compass and a Protractor. Besides this, pupils were supposed to construct their work on plain papers. Teacher ‘A’ noted lack of learning materials as part of the challenges in teaching the topic so did Teacher ‘B’ and Teacher ‘C’. Teacher ‘C’ explained that lack of mathematical instruments was the main hindrance for the pupils to learn the topic. He further said that pupils were supposed to use plain papers even when practicing how to construct but they were using grid books, hence at times they could take advantage of the lines in their books than constructing their own. During the FGD’s pupils also brought up the issue as the main challenge to their learning constructions. The following is what the pupils said: “ *Our parents buy for us the mathematical sets when we report for school in grade 10 as a requirement for school. But*

*with time we lose them and it is difficult to go back to ask for money to buy another one. There is also too much stealing among ourselves such that even if a mathematical set is replaced, it is easily lost within a short period of time”.*

Teacher ‘C’ explained that he notified the pupils on time to find the required instruments for the topic but not all of them managed to provide them. The following is what he said during a post lesson interview.

*When I just introduced the topic, I chased all the pupils who did not have the instruments to go out and find something they could use from other pupils in other classes. But they just stood outside without going anywhere. This attracted the Deputy Head Teacher’s attention who brought them back and told me to allow the pupils to learn even without instruments. So, it’s very difficult even to bring up measures which can help the learners to learn without support from administrators as they don’t understand the challenges we go through. The learners also are a letdown as they lose their mathematical sets before this topic is taught to them.*

During class observations, it was observed that most of the learners did not have all the required geometric instruments which made it difficult for them to learn. Out of desperation some of them copied the constructed work from the board after asking for instruments from friends who had finished constructing, while others used their free hands to construct. It was also observed that some pupils improvised pieces of paper to construct.

**Understanding of Construction Language:** During interviews, the teachers expressed concern over the lack of understanding of construction language among the learners. Teacher ‘C’ explained that because of the poor background of the learners in Mathematics it was difficult for them to understand the construction language. He gave an example that if the pupils were told to bisect an angle or asked to draw an equidistant from the line A and B they failed, language was also a barrier. Teacher ‘B’ also said that the pupils understood the construction language with a lot of difficulty. Whereas Teacher ‘A’ said that the pupils understood the language but they easily forgot due to memorization of terms.

During the FGDs the pupils said the construction language was difficult to understand. One of the pupils gave an example of shading a region.... *that you can be asked to put a point or locate a point or shade a part closer to point A than point B.... the questioning techniques are difficult to figure out what really is required of us to do.*

**Bridging of the Gap of Primary and Secondary Content:** The teachers explained that the construction topic was difficult to connect with other topics from primary school. Teacher ‘A’ and ‘B’ said that ‘angles’ as the only topic which related to construction. Teacher ‘C’ stated that the pre-requisites should be put in primary school syllabus to help the learners to get used in the holding of the pair of compasses. Teacher ‘A’ explained that he always introduced the learners to the topic by first teaching them how to hold the pair of compasses by letting them draw different sizes of circles. This was also observed by the researcher.

### **Difficulties in Teaching Constructions:**

Not only did the pupils face difficulties in learning the constructions but the teachers too had difficulties in teaching the topic. The following were the codes which made up this category.

**Teachers Lacking Preparation of Lessons:** During the lesson observation, the study showed that teacher 'A' and teacher 'B' taught all the three lessons observed without lesson plans. This showed that they were not prepared enough for the lessons. In post lesson interviews, they said that they used their experience to teach as they had been teaching for so many years. Teacher 'A' and Teacher 'B' taught their lessons without lesson evaluation and a summary of the main concepts during their lessons. During the post lesson interviews, the teachers said the lessons were successful as they managed to teach all they had planned to teach. Teacher 'A' further explained that what was important was to make sure that the pupils constructed along with the teacher.

**Using Teaching Materials in Classrooms:** Resources included the use of teaching aids such as the chalk board. Teacher 'B' and 'C' were very much organised when using the chalk board as it was cleaned and lines drawn accordingly. Teacher 'A's board work was poorly done. In two lessons the board was partially cleaned such that it was a problem for pupils to copy the right work from the board. All the three teachers had Pair of Compasses but only Teacher 'B' and 'C' had the Board Ruler. Teacher 'A' used his free hand to draw shapes on the board which made some pupils do the same.

**Teachers Lacking Teaching Materials:** Teacher 'C' expressed concern over lack of teaching materials. Teacher 'A' said the teachers improvised some materials for themselves. During the post lesson interview teacher 'C' cited the following: *We made a request to the school administration to help us with the teaching materials needed for this topic and transformation. The right procedure was followed to have the instruments procured but we were told that the school had no money to procure such materials at that moment. Hence, we just asked for the compass from our neighboring schools. The Head teacher also told us to write a letter to our immediate neighbors this basic school so that they can help us some board instruments. We were given some, of which the main instrument the compass is not in good condition. One of the teachers bought a compass which is quite good therefore we all use the same one hence we change the teaching time to give ourselves turns to use it. The National Science Centre also promised to give us something after all the other provinces have been given but this will take long for us to have the instruments hence all we have to do is to improvise.*

**Teachers Lacking Support from Administrators:** The narration above from Teacher 'C' is a clear indication that the teachers were lacking support from administrators to teach practical topics. Hence this code emerged as the teachers had no proper instruments to use during the teaching of the topic.

**Teachers Shunning to Teach the Constructions Topic:** The documents analysis showed that some teachers shun teaching the constructions topic especially at grade nine level. The schemes of work at the department showed the constructions topic to be taught in the second term but for some two teachers in the department the records of work did not show that the topic was taught.

During the FGD's with the pupils, some of them cited that it was their first time to learn the constructions topic.

**Difficulty in Achieving Intended Objectives:** The lesson objectives were supposed to be found on the lesson plans of the teachers, but only one teacher taught with lesson plans. Teacher 'C' had all the detailed lesson plans. For example, Teacher 'C' had this objective for the first lesson observed:

*By the end of the lesson pupils should be able to construct different types of angles. Doing so in four out of five questions is the acceptable standard level of performance.*

He explained that even when an objective is set for eighty percent of the pupils getting all the questions correct, it was difficult to achieve as some of the pupils did not do the work at all as they had a negative attitude towards the subject. Teacher 'A' and 'B' had no lesson plans. During the post lesson interviews, their self-evaluation for the lesson was based on the subtopic taught.

**Lacking Support from Parents during Homework:** During the FGD's some pupils said that their parents were not very knowledgeable on the constructions topic hence it was difficult for them to be helped. They said that much of the work given to them was done in school with the help of fellow pupils. Teacher 'C' also said that even at home they did not have the instruments so they did not get any help. Whereas Teacher 'B' said some did receive help from home but these were very few. Teacher 'A' said the pupils still consulted him in school as it was difficult to get help from home.

**Parents Providing Learning Materials:** During the FGD's some of the pupils said their parents could not afford to buy for them all the materials needed for them to use in school. For the mathematical sets, some of them explained as follows; *our parents cannot manage to buy all the books we need as we are not the only ones who go to school.*

**Teaching Large Classes:** All the three teachers said that they had large classes to teach a practical topic effectively. Teacher 'C' said that the class sizes were too large such that it was difficult to look at learner differences. He further said that it was difficult even for the learners to construct properly as they sat three per desk instead of two. Teacher 'B' said due to large numbers he depended on using the board to cater for everyone as it was difficult to give individual instructions.

**Pupils Working Hard:** During the FGD's the pupils said they were supposed to work hard in the Geometric Construction topic as it was a practical topic. They said they easily forgot the concepts without practice. Teacher 'B' said that he always reminded the learners that the topic was very useful for examinations, hence the need for them to work hard.

### 5.7. Class Management

This category is the third for the theme 'challenges that influence the teaching of Geometric Construction.' The codes were discussed as follows:

**Learning Environment:** During interviews, teachers described a classroom environment which was conducive for teaching and learning. They talked about managing their classes well and using learner-centered approaches of teaching. But during observations most of the issues raised by the teachers were not practically seen. The lack of teaching and learning materials and the large numbers of pupils in classes diverted the teachers in a different way.

**Pupils Losing Interest:** Some learners got frustrated of not having the required instruments needed for construction. Hence, they lost interest in the lessons. The teachers, too, were helpless for example in Teacher 'C's second lesson, he asked the learners who had no instruments to raise up their hands. When they did, he found that the number was too big, hence he did nothing about it.

**Controlling of Classes:** It was observed that it was difficult for the teachers to control their classes due to too much noise which came about because of lack of learning instruments. The learners moved from one person to another in search of instruments. Hence, it was difficult for the teachers to manage the classes well. This was more evident in teacher 'B's class.

**Questioning Techniques:** The questioning ranged from open ended to closed-ended. The distribution was not fully balanced for all the lessons observed as the lessons, were purely teacher-centered. Only the pupils who raised their hands to answer were chosen by the teacher. The non-volunteers were not given chance to say anything. For teacher 'C', he managed to get answers from the girls compared to the other teachers. The lessons were mainly teacher-centered, even though the teachers said their lessons were learner-centered. The pupils were less involved. The interaction between teacher and learner was mainly teacher-dominated. For example, in terms of teacher-pupil talk the following happened for Teacher 'C' in one of the lessons:

Table 3: *Teacher-pupil talk*

	Teacher	Pupil
Talk	√√√√√√√√√√√√√√√√√√√√√√	√√√√√√
Totals	18	6

The teacher dominated in the lesson as he used the demonstration method coupled with the expository method. The pupil talk was done in chorus answers as the teacher concentrated on finishing what he had prepared for the learners.

**Summarizing of Main Points:** The summary of the main points of the lessons was not done for all the lessons observed. The teachers did not go through to summarise the main points of the lessons before leaving the classrooms. There was no linkage to the next topic for the lessons presented.

**Evidence of Learning:** In some instances, there was evidence of learning as the pupils were able to answer questions with less difficulties. But in some cases learners were lost as they did not know how to go about solving even the examples they did in class with the teacher. During



FGD's some pupils explained having difficulties to tackle construction questions on their own. They said that they forgot easily but followed well when doing it with the teacher. In Teacher 'C's class, evidence of learning was seen compared to the other two teachers as he gave the pupils enough exercises and home works.

## **6. Conclusion and Recommendations**

### **6.1. Conclusion**

The study established that teachers used mostly the demonstration, teacher exposition and discussion methods in teaching Geometric Constructions. The study further found that both teachers and learners had challenges in teaching and learning of Geometric construction due to lack of instruments on both the side of the teacher and the learners. Teachers had sufficient mathematical knowledge for teaching the topic. However, their performance in class was affected due to lack of resources. The teaching of the topic was superficial because mathematical reasons were not being given for various construction procedures. The procedures were mostly based on 'do as I say'. Learners were not being encouraged to justify the steps they used in the constructions. They were not being challenged to come up with different ways of producing the desired result. According to Hiele's (1986) theory on levels of thought in geometry, most of the teaching and learning was at the visual level of the five levels progression, i.e. learners mostly identify and operate on shapes and other geometric parts based on the appearance. Occasionally, there was evidence of the descriptive level and abstract levels whereby properties of shapes were a factor in either deciding on what to do or to justify what had been done. The top three levels of progression in Van Haile's (1986) model have abstract, formal deductive and nature of logic laws whereby properties are ordered and one property precedes or follows another property; dealing with deduction and learners proving theorems deductively and demonstrating understanding the structure of the geometric system; and dealing with rigor with learners establishing theorems respectively (Hiele, 1986). Nothing of these top three levels on the Van Hiele's (1986) model was seen either in the teaching or learning of Geometric Constructions. The environment in which Geometric Constructions was taught could be a major contributor to this situation. The pupils had a poor mathematical foundation on the topic from primary school. The teachers did not try to bridge the gap between what was learnt in primary school with new ideas in secondary school. They stated that the topic had no pre-requisite knowledge hence, teaching was a challenge. Pupils lacking materials was the major challenge as the topic requires the use of Geometric instruments. This made the pupils who had no instruments to lose interest. It was difficult for the pupils who had no instruments to work hard. Poor learning attitude among pupils made the teachers not to teach as required.

Understanding of construction language was another factor which led to poor understanding of Construction concepts. The pupils observed the demonstrations of the teacher but did not understand the language well. Teachers did not give enough time to the learners to interpret the Construction language. More practise through speech would have been helpful for the learners to understand. However, they imitated the language and forgot easily. The teachers could have used good questioning techniques to stimulate the learners to participate fully not just through hands-on but also through minds-on activities in order to learn the language. Relating the construction to real life situations when explaining new terms would have been helpful.

But the teachers rushed through the topic to cover the syllabus. Teachers also had teaching challenges as they just had to improvise all the required instruments for use. The lack of materials was attributed to lack of support from administrators. Furthermore, the parents did not support the teachers as they did not provide the instruments for their children. This led to teachers failing to achieve their teaching objectives. The class sizes were too large for a practical topic like Constructions. Therefore, monitoring of pupils was difficult and also giving individual instructions to learners was not done. The pupils sat three per desk resulting in them having restricted movements when constructing. The learning environment was not conducive for the topic. Due to lack of instruments and large numbers in class the classroom control was poor and there was no evidence of learning taking place for most learners. Only few learners managed to submit their books for marking as others did not manage to finish their work. The study further found that there was lack of follow-ups on the side of teachers which made the learners to lose concentration in the lessons. When it came to hands on activities learners needed to be monitored for them to maintain the interest. The learners had poor grasp of Geometric concepts, unable to visualise objects, comprehending the language or Geometric Construction terms used in Geometry in general. The challenges faced by learners (according to them) were caused by having so much to do in the subject. It was also established that for either sex, both learners, irrespective of gender, encountered difficulties in learning Geometric Constructions, though the girls had more difficulties than boys. This was evident in teacher 'A's class where some of the girls gave their books to the boys to construct for them without even paying attention to the way the boys were doing it. While from the teachers' point of view it was indicated that female learners had the most difficulties than male learners.

## 7.2 Recommendations

Recommendations for practice were as follows:

- In view of weaknesses in teachers teaching Geometric Constructions, and use of teaching methods that did not promote higher levels of performance in Geometry, Continuous Professional Development Programmes should be conducted on this topic in order to enhance the in-depth knowledge on the topic to enable the teachers to teach with confidence.
- In view of the challenges arising from the lack of appropriate facilities, schools should procure instruments and other resources required both by teachers and learners so as to promote effective teaching and learning.
- The National Science Centre should also come in to help all the schools with the right instruments to use in Mathematics.
- Teachers should be encouraged to plan their lessons effectively and they should find time to research as much as possible so that they have the knowledge required to teach the topic.
- Teachers should be encouraged to research and plan their lessons together so that they complement each other's knowledge and ideas required to teach the topic.
- Learners need to have access to geometrical instruments to enhance quality of learning.

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