



DETERMINING THE EFFECTIVENESS OF INSTRUCTIONAL METHOD USED BY SENIOR GRADE SECONDARY SCHOOL MATHEMATICS TEACHERS IN PROMOTING STEM EDUCATION IN ZAMBIA.

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Abstract

The study was conducted to determine the effectiveness of instructional methods used by senior grade secondary school mathematics teachers in promoting STEM Education in secondary schools in Luampa District. This study was influenced by the current poor performance of learners in mathematics in the past years in secondary schools. The researcher realized the mounting pressure on the need to change the way teachers conduct their lessons characterized with teacher-centered approaches to approaches that integrate STEM Education. Instructional methods that encourage learners to be in the forefront in searching for their knowledge using various representations that foster proper understanding.

The purpose of this study was to determine whether or not teachers of mathematics involve instructional methods that promote STEM Education. The study adopted both qualitative and quantitative approaches. The respondents to the study were learners of senior grades, teachers of mathematics, and other STEM subjects. Questionnaires were administered to collect data. Teachers' interviews were conducted with three teachers of other STEM subjects being; Information and Communication Technologies and Science. In interpreting data Simple Statistical procedure known as Microsoft Excel was involved to turn quantitative data into meaningful data while qualitative data was analysed by categorising or grouping the emerging aspects of behaviour.

The results indicated that teachers fail to integrate STEM Education into their instructional methods due to some challenges faced. The identified challenges were: lack of modern STEM laboratories vanished with latest textbooks and equipment, some institutions were not connected to hydroelectric power sources, teachers lacked knowledge on the operation of technological tools, a shortage of suitably qualified STEM teachers, and negative attitude of some administrators in supporting STEM activities.

KEYWORDS: *STEM Education, instructional methods, qualitative, quantitative, senior grades, questionnaires.*

INTRODUCTION

The study intended to determine the effectiveness of instructional methods used by Senior Grade Secondary School mathematics teachers in promoting STEM Education in secondary schools of Luampa District. It has been observed that poor performance in mathematics, which is a fundamental core content area in secondary education [1], is a worldwide concern as was evident from high stake test results, and in international testing like Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) [2]. Poor performances in mathematics discourage learners to continue taking mathematics-related courses at a higher levels of education [3].

The poor performance trend in mathematics simply points to the factor that the instructional strategies used in teaching adversely affect students' achievement in that particular subject. It is observed that nowadays there is an emphasis on the promotion of instructional strategies that include STEM Education. It is for this reason that the study would want to examine the levels to which teachers of mathematics promote the integration of STEM Education in the teaching of the subject at senior grades in the secondary schools to prepare students for their future careers that demand mastery of STEM Education to be productive.

RATIONALE OF THE STUDY

The purpose of the study was to determine the effectiveness of instructional methods used by Senior Grade Secondary School Mathematics teachers in promoting STEM Education. It also examined instructional methods used in teaching mathematics to ascertain the levels that promote the integration of STEM Education.

There is pressure mounting on integrating STEM Education into the instructional methods used in teaching mathematics to satisfy the use of various teaching methods that allow the diversity of

learning needs of students be met [4]. Students' academic achievement in mathematics should be raised as the subject is regarded as the backbone to other core subjects. The subject further prepares students for their career life by equipping them with the necessary skills. This study allowed educators to know if teachers of mathematics integrate STEM Education into their instructional methods and the commonly used teaching methods are identified. The challenges encountered in integrating STEM Education in teaching methods used are highlighted. Based on the findings, recommendations are made to the Ministry of General Education and other stakeholders so that appropriate interventions are made.

The changes in instructional methods can only be made if teachers have broad knowledge in the subject itself, in pedagogy, and in their students' background [4]. The students' academic attainment can be truly improved when teachers integrate the knowledge they have on the mathematics curriculum, and how to effectively teach it, and how they assess students' mastery of the covered content [5]. This also influences the change in the ways teachers teach.

LITERATURE REVIEWED

The common instructional methods used in the teaching of mathematics are the traditional methods that negatively impact learners' achievement [6]. Mathematics teaching is mostly based on traditional skills models that involve memorization and rote recitation that fail to satisfy the use of a variety of learning styles. Several researchers argued that variation of teaching methods in mathematics is important because different teaching methods draw attention to different competencies in mathematics [7]; [8]; [9].

Mathematics is a subject among those regarded as very important to the life of learners and is considered a backbone of many other subjects [3]. The subject stresses the need to promote the

practicability aspect to the life of learners. Instructions used in teaching mathematics are encouraged to be changed due to the increased use of technology and the mounting pressure on the changing demands in places of work [10];[11]; [12].

There is an emphasis on the shift from traditional instructional methods that base their teaching on memorization of isolated facts and procedures to ones that promote the integration of STEM Education that equip the 21st-century students with life skills so that they are valued members of their respective societies [12]. Integration of STEM Education would not only influence the potential to achieve more but would also lead to the flexibility of services and enhance their quality [13]. The shift in the use of technology is not all about the technology itself [14], but the interest is the change in teacher's practice [15], motivate learners, and create a friendly learning environment as the right resources are used to transform and energize their practice. It is observed that the current teaching of the subject emphasised on acquiring mathematical skills and techniques to solve mathematical problems only without considering the connection of such problems to real-world situations [15]. The teaching further encourages supplying the correct answers to an asked problem which may fail to develop a clear idea of the mathematical fundamental concepts in learners.

STEM Education

STEM Education is an instructional strategy that is an interdisciplinary approach to learning [16] that is explained as; Science, Technology, Engineering, and Mathematics (STEM). The aim of introducing STEM Education is to equip learners with scientific, technological, engineering, and mathematical life skills that are mandatory in life within and outside the school life of learners. As it is observed, learners that lack STEM Education skills are regarded as not having the requisite background of high school mathematics and will not be able to enter courses that depend on those

skills later in their life [17]. The teaching of science and mathematics is done in such a manner that satisfies technological and engineering design processes. STEM Education ensures that life skills like problem-solving and critical thinking are enhanced in students early [2] to establish a foundation in equipping them with skills needed in a higher grades or life after school. The purpose of integrating technology in teaching is to enhance learning and teaching as it supports both learners and teachers [18]. The need to have a clear understanding of the changes that must be done in regards to instructional methods used for the learning needs of our 21st-century learners to be satisfied [14].

A number of challenges encountered by schools result in the failure of implementing STEM - based curriculum [16]. Among many such identified challenges or barriers were lack of laboratories, shortage of equipment and chemicals, and inadequate STEM-trained teachers, particularly at secondary school section. The study tried to gather initiatives put in place by countries, Zambia inclusively, to encourage the implementation of STEM-based curriculum that has been noted to have been recently over-emphasised worldwide [19]

(a) Establishment of Centre of excellence - Some schools (Kasempa and Nkadabwe secondary schools in North-Western and Southern Provinces respectively) have been piloted into centres of excellence in teaching and promoting STEM subjects that are identified as the hub in transforming economies of countries. In these secondary schools, the government of Zambia and some collaborating partners embarked on constructing modern equipped infrastructure, furnishing them with up-to-date STEM literature and highly qualified human resources.

- (b) **Formulation of Policies and Government bodies** – some policies were formulated by established government bodies like the National Science and Technology Council (NSTC) to monitor and give guidance on the implementation of the STEM curriculum.
- (c) **Revision of Curriculum** – like it is in other countries, Zambia also embarked on revising the already existing curriculum in the 2013 period to establish an inclusive STEM curriculum. In this revised curriculum, some topics that promoted STEM education were introduced. The revised curriculum promoted multidisciplinary connections and integration among STEM subjects to create students' awareness and interest in STEM fields.
- (d) **Teacher training** – Teachers' trainings, in implementation of STEM curriculum, are conducted to both in-service and pre-service teachers. To already serving teachers short or long trainings are offered. A good teacher's subject knowledge is needed in the teaching of STEM subjects [20].

METHODOLOGY

The study was undertaken in the Western Province of Zambia, particularly in Luampa District. This district is one of the recently created in 2013. It used to be part of Kaoma District. The study was carried out in two established secondary schools of the district at the time it was undertaken in 2019. The two secondary schools being located in a rural setup, the researcher wanted to establish the levels to which the secondary schools satisfy the government policy in implementing instructional methods that promote STEM education in the teaching of mathematics.

The research design used in this study satisfied the characteristics of a descriptive survey. A descriptive survey involves the use of interviews and administering questionnaires in collection of data. The type of data collection method was chosen as it allowed the researcher to gather the

prevailing situations in schools on the topic being studied. A descriptive survey also encouraged the researcher together with respondents to offer appropriate solutions to the problems [21].

Questionnaires were formulated and administered to establish the existing situation in schools in regards to the topic. Permission was obtained from the District Education Office before the researcher went into schools to administer the questionnaires. The researcher notified schools before visiting them. Random sampling was followed in the identification of learners to be respondents. This type of sampling was followed as learners were found writing their end-of-term examinations.

This research satisfied construct validity by ensuring that the test items formulated covered content that needed responses that adequately satisfied the research objectives. Reliability was satisfied by making sure the questions set in the questionnaires needed responses that depended on the prevailing situation on the way teachers of mathematics involved instructional methods that promoted STEM Education. The test items constructed in the measurement instruments were objective.

Data captured through the use of questionnaires from learners and teachers was analysed by involving qualitative and quantitative techniques. Quantitative data was analysed using a Simple Statistical procedure known as Microsoft Excel that assisted in constructing diagrams like graphs, charts, and table while qualitative data was analysed by categorising or grouping the emerging aspects of behaviour [21].

RESULTS AND DISCUSSIONS

Table 1: Involvement of learners in the teaching and learning process.

SCHOOL	LEARNERS' INVOLVEMENT IN THE LESSONS			Total
	Always	Sometimes	Not involved	

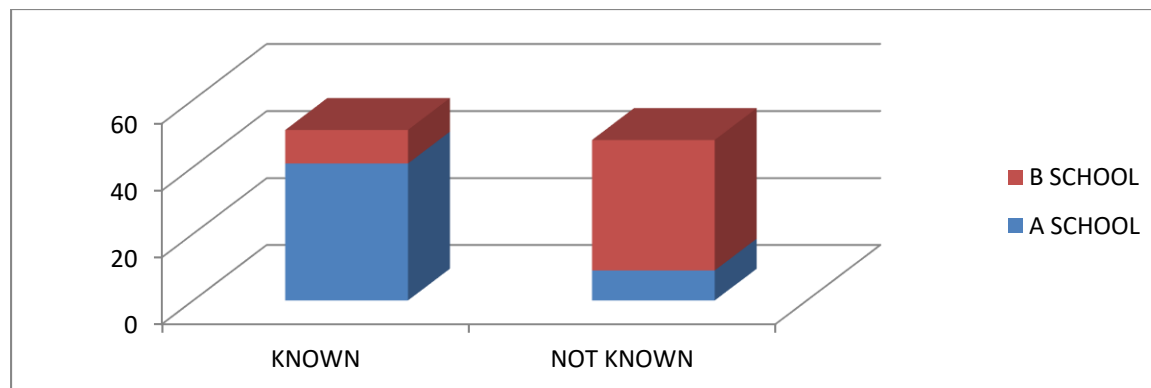
SCHOOL A	9	16	25	50
SCHOOL B	5	11	33	49
TOTAL	14	27	58	99

From the table above 14 learners indicated that they are always involved, 27 learners are sometimes involved and 58 denied being involved at all. Few learners (14 learners) are involved, as it is evident from the two schools, these could be learners regarded as fast learners that always dominate the flow of the lessons in most situations. The 27 learners are those learners that are accidentally involved and the 58 learners are left to struggle on their own without the teachers' attention. Such learners fear to ask teachers when they are not clear with the content being presented. This clearly explains in itself that most teachers involve teacher-centered approach to teaching than the most needed learner-centered approach.

Meaning of STEM Education

41 learners, which was 82%, from **School A** knew and understood what the initials on STEM Education represent while 9 learners (18%) showed ignorance. On the other hand, **School B** had 10 participants (20.41%) who had knowledge on STEM Education while a huge number of 39 participants (79.59%) failed to define it. The 3 grade 11 learners who participated in the study showed to have an idea of STEM Education though could not define it. This indicated that there was still very little work done by teachers in integrating STEM Education in the instructional methods used in teaching and learning of mathematics [16]. The graphical presentation of learners' understanding of STEM Education is as indicated in figure 1.

Figure 1: Meaning of STEM Education.



Common instructional methods used in teaching.

It was evident that teachers resorted to the traditional way of teaching where; firstly, they teach each discipline separately [22], and secondly, the teachers (Source of knowledge) play major roles in presenting the knowledge to learners who are passive (empty vessels). Teachers have adopted this type of teaching because they believed that learners find it difficult to take an active part in knowledge generation especially when dealing with new topics. This hinders teachers' progress as planned.

Table 2: Common instructional methods used in teaching.

S/N	INSTRUCTIONAL METHODS	Number of teachers of School A using the stated method.	Number of teachers of School B using the stated method.
1.	Questions and Answers	3	2
2.	Direct Instruction	2	3
3.	Group Discussion	3	3
4.	Lecture	2	4
5.	Inquiry-based learning	1	-

By analysing the responses it is observed that 4/5 the suggested instructional methods fall under teacher-centered approach (Questions and Answers, Direct Instruction, Group Discussion and Lecture) while only 1/5 of the responses is learner-centered approach (Inquiry-based learning) this simply indicates that teachers from the two institutions mainly use the traditional way of teaching in which learners remain as observers.

CONCLUSION

From the responses gathered through the questionnaires administered to teachers and learners, and from teachers' interview conducted, the researcher made a number of observations in relation to the research questions:

1. Which instructional methods do Mathematics teachers use during the teaching and learning of Mathematics at senior grades?

The teachers' instructional methods used in teaching mathematics are characterised by teacher-centered approach that lacks the use of real-life scenarios that promote learners' engagement in learning. The teacher-centered approach is attributed to the failure of learners in developing a conceptual understanding of mathematical processes [23].

2. Do the instructional methods used by Mathematics teachers during the teaching and learning of Mathematics promote STEM Education?

Some undertaken studies stated that teachers tend to teach the way they learned the time they were in school. Despite great pressure on changing instructional methods from those that regard learners to be at the receiving end to those that encourage learners to be at the hub of searching and generating new knowledge for themselves, if they are to be held accountable for meeting high

academic standards. According to Table 2, it is evident that teachers from the two institutions mainly use the traditional ways of teaching. This was evident in the results from similar researches conducted [24].

3. What are the challenges faced by mathematics teachers in using instructional methods that promote STEM Education?

Teachers in secondary schools in Luumpa District face some challenges in promoting STEM education in their instructional methods used. The noted challenges were:-

- Lack of appropriate textbooks and inadequately vanished STEM laboratories,
- Negative attitudes of some learners have towards STEM subjects,
- Teachers lack adequate knowledge on how and when to integrate STEM education, and
- Lack of suitably qualified teachers in STEM disciplines.

RECOMMENDATIONS

The recommendations made to school administrators, the Ministry of General Education and concerned cooperating partners are given in line with the challenges faced in the promotion of STEM Education in teachers' instructional methods used.

1. The school administrators to intensify on the conduct of Continuing Professional Development meetings.
2. The schools' administrators, being the first internal monitors, should ensure that teachers use learner-centered instructional methods in their lesson delivery.
3. The Ministry of General Education to improve staffing of qualified STEM teachers by employing teachers in regards to areas of needy.
4. The Ministry through Curriculum Development Centre to produces and supply textbooks that satisfy the revised curriculum of 2013.
5. The Ministry through collaboration with cooperating partners to construct modern STEM laboratories and vanish them with modern STEM equipment.

6. The Ministry to conduct in-service training for already serving teachers so that they are vested with STEM education knowledge and skills that will make them know when and how to integrate STEM subjects in their teaching methods.

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