An analysis of the challenges faced by teachers in the delivery of Science, Technology, Engineering and Mathematics education in rural day secondary schools in Zimbabwe

Abstract: This study was prompted by the recent surge of interest in engaging secondary schools in integrated Science, Technology, Engineering and Mathematics (STEM) learning in Zimbabwe, which has created a demand for guidance about what constitutes ‘effective’ integrated STEM education. The purpose of the research was to look at challenges faced by teachers in the delivery of STEM education in rural day secondary schools in Zimbabwe. Premised on the qualitative research approach, this study adopted the phenomenological perspective, which, within the interpretive paradigm, uses a naturalistic approach that seeks to understand phenomena in context. The population comprised of Heads of Schools, Heads of Departments (HODs) and STEM teachers. A convenient and purposeful sample of one district and within that district five rural day secondary schools was selected. Data were generated through interviews and focus group discussions. The study found that schools did not have enough resources for quality teaching and learning of STEM subjects. School Heads lacked the knowledge to supervise STEM teachers. It is therefore, recommended that government funds rural day secondary schools meaningfully to improve the quality of STEM education. There is also need to undertake wider stakeholder consultations, advocacy and collaboration on STEM issues in a bottom up approach.

Keywords: STEM education, Rural day secondary schools, Teachers, Challenges.

INTRODUCTION

The success of the first launch of the artificial earth satellite in 1957 by Russia, became a blow to other countries, and necessitated countries to compete against each other to lead in the discipline of STEM, (Ramli, Talib, Manaf & Hasson, 2017). The United States of America and Singapore began to include STEM as one of their key syllabuses in the school curriculum in 1962 and 1982 respectively (Banks & Barlex, 2014). The objective of STEM education is to prepare the future workforce by enabling them to use their expertise to support the government efforts and also to develop scientifically literate citizens.

Studies funded by the European Commission and those conducted by Science, Technology, Engineering and Mathematics (STEM) communities such as the STEM Alliance have highlighted major issues regarding the situation of STEM in European education systems: the low attractiveness of STEM studies and careers, and the unmet labour-market needs in STEM-related sectors that are expected to grow in the future (Han, Yalvac, Capraro & Capraro, 2015). In Africa, rural day secondary schools often struggle with attracting and retaining qualified teachers especially in Science subjects (Gadzirayi, Bongo & Bhukuvhani; 2016). Yet the recent surge of interest in designing programs that successfully engage students in integrated STEM learning experiences has created a demand for guidance about what constitutes “effective” integrated STEM education (Buxton, 2001). It was therefore necessary to examine the lived experiences of rural STEM teachers, including their perceptions on the challenges of rural STEM teaching and learning due to the fact that consequences of rural teacher attrition are dire for rural STEM learning in particular.

For many years in Zimbabwe, there has been no national system of evaluating the performance of secondary schools’ STEM related subjects while there was no comprehensive data on the quality of teaching and learning of the integrated STEM education system in Zimbabwe (Gadzirayi et al, 2016). Research findings published by the World Bank and Elsevier highlighted that Zimbabwe’s population with STEM education stood at 0.04% (Moyo, 2015). Sciences and Mathematics pass rates decreased in 2015 by 29.4% as compared to 2014 with Chemistry having dropped by 3.7% followed by Human and Social Biology which downgraded from 30% to 25% while Integrated Science had an insignificant drop of 0.03% (Gadzirayi et al, 2016). The survey went on to mention that although the national pass rates...
in the Science subjects were very high, what was worrisome was that the number of candidates who attempted these subjects at ‘A’ Level was very low. In 2014 those students constituted less than 10% of the ‘A’ Level candidates.

### Table 1. Ordinary Level Candidature and Science Subject Entries

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Candidature</th>
<th>Integrated Science</th>
<th>Biology</th>
<th>Chemistry</th>
<th>Physics</th>
<th>Computer Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>91,445</td>
<td>71,112</td>
<td>14,016</td>
<td>802</td>
<td>889</td>
<td>1,088</td>
</tr>
<tr>
<td>2010</td>
<td>133,573</td>
<td>119,540</td>
<td>16,903</td>
<td>934</td>
<td>1,152</td>
<td>1,190</td>
</tr>
<tr>
<td>2011</td>
<td>136,262</td>
<td>130,520</td>
<td>18,284</td>
<td>1,443</td>
<td>1,146</td>
<td>1,295</td>
</tr>
<tr>
<td>2012</td>
<td>268,854</td>
<td>193,968</td>
<td>21,685</td>
<td>2,135</td>
<td>1,905</td>
<td>1,342</td>
</tr>
<tr>
<td>2013</td>
<td>285,260</td>
<td>202,922</td>
<td>20,922</td>
<td>2,739</td>
<td>2,408</td>
<td>1,533</td>
</tr>
</tbody>
</table>

*Source: BUSE Baseline Survey (2015)*

In her address at a Chinhoyi High School workshop attended by Science teachers in Mashonaland West on 9 July 2018, Mrs Ta, The Zimbabwe School Examinations Council (ZIMSEC) Physics subject manager lamented the low uptake of Science by ‘O’ Level students. She had this to say,

*In 2016 the majority of learners (213983) studied Integrated Science as compared to 7194 for Chemistry. The trend is similar when compared with other pure Sciences for the past 30 years. Of the 7194 Chemistry candidates only 431 took the practical test.*

It had to be noted that opting to study Integrated Science instead of pure Physics, Chemistry and Biology denied many learners the chance to proceed to Advanced Level or to a Science related career (Ta, 2018). Graduates who lacked Science practicals, technical and investigative skills were found to be ill-equipped for progression to higher education in Sciences, employment in Science related fields and for solving real life problems (Ta, 2018). Currently, Zimbabwe relies mainly on developed countries such as China, Japan, Korea and Malaysia for technology in spite of the large number of learners taking science at Ordinary Level. Tooth picks, for example, are imported from China as if there are no trees in Zimbabwe.

In trying to find solutions to these challenges, many initiatives and programmes have been pursued, such as “The new skills Agenda” initiative from the European Commission to focus on improving the quality and relevance of STEM skills development, to promote STEM studies and careers and to support teachers’ professional development (Gadzirayi, et al, 2016). In the same context, the Texas instruments and European Schoolnet, with the support of Scientix, joined forces to conduct a study on STEM education, policies and STEM teachers’ practices (Han, et al. 2015). The report’s key findings all painted to shortcomings in five key areas covering; (1) pedagogical approaches used in STEM teaching, (2) access to and use of resources and materials, (3) professional development and support for STEM teachers, (4) experience and educational level in STEM teaching and (5) teachers’ attitude and influence of the environment. While the above is true for some European countries, Africa faces its own fair share of STEM challenges. Africa, a continent with fifty-four countries, has no more than 300 institutions that fit the definition of a
college or university (Demetria & Mahona, 2020). Niang (2019) co-founder of Akon Lighting Africa, writes in the report that, 60% of Africa’s 1,25 billion people are under the age 25% of these enrolling for tertiary education. Mupa (2012) highlights the following challenges that need to be attended to in order to improve STEM education across Africa; inadequate scientific infrastructure, shortage of qualified teachers, inadequate teaching and learning materials, lack of adequate practical exposure and curriculum deficiencies.

Research Questions

The variables pointed out above by Mupa (2012) were used to design some of the questions to probe the factors impacting on the provision of quality in STEM subjects in rural day secondary schools in Zimbabwe. The specific research questions addressed in this study are;

1. What challenges are faced by teachers in the delivery of STEM education in rural day secondary schools in Zimbabwe?
2. What is the status of STEM education curriculum in rural day secondary schools in Zimbabwe?

The above research questions seek to address the following objectives:

1. Examine the challenges faced by teachers in the delivery of STEM education in rural day secondary schools in Zimbabwe and
2. Analyse the status of the quality of STEM education in rural day secondary schools in Zimbabwe.

THEORETICAL FRAMEWORK

This study employed the Systems Theory to operationalise how quality assurance can be used as a lense to examine STEM education in a school system (Mupa, 2012). The foundation of the Systems Theory is that all components of an organisation are interrelated and that changing one variable might impact many others (Giddens, 2009; Turner & Baker, 2019). Within system thinking, it is important to note the sub-systems relationships, highlighting the methods of teaching and the teaching/learning process. The system can be composed of subsystems as well as units or parts making the whole interaction. Once organised, a system is not simply a collection of parts but a functional entity that has properties that cannot exist independently as a collection of parts, (Mupa, 2012; Jung & Vakharia, 2019). In order to be a functioning system, the total system has to define its objectives and performance measures; the environment has to be considered as an influencing factor; the resources must be determined, the components of the system must be defined and the management of the system must be set, (Churchman in Mizikaci, 2006).

As organisations are composed of interdependent components that function together, hopefully towards predetermined goals that are driven by policies, strategies and realignments ((Mupa, 2012; Jung & Vakharia, 2019), systems thinking requires that organisational components constantly review, re-evaluate and stabilise in the short-term so that the entire system plans strategically to align resources and identify highly effective functions. Systems thinking drives continuous improvement and discourages organisations like schools and individuals from repeatedly making the same mistakes. Schools, therefore, are organisations that have various sub-systems which have to work together in order to achieve quality in STEM education.
Operating from within systems theory, Garira (2020) developed the unified conceptual framework for quality of education in schools which is depicted on Figure 2. Garira (2020) argues that instead of focusing on a single level of the education system, such as the national, the school, or the classroom, to conceptualize quality of education, the unified conceptual framework for quality of education in schools considers all these levels to conceptualize quality of education. Systems theory, through the unified conceptual framework for quality of education in schools considers all these levels to conceptualize quality of education. Systems theory, through the unified conceptual framework for quality of education in schools considers all these levels to conceptualize quality of education. Systems theory, through the unified conceptual framework for quality of education in schools considers all these levels to conceptualize quality of education. Systems theory, through the unified conceptual framework for quality of education in schools considers all these levels to conceptualize quality of education.

What is unique about the systems theory is that it examines the relationship between individual monads of a group. System theory is also interested in the relationship between the environment and the monad, as well as the environment and the entire systems as an entity (Garira, 2020). Systems theory is extremely applicable in the delivery of STEM education because schools are inherently open systems (Sias, 2009). Systems theory provides a basis for schools to examine quality from inputs, through process to output within particular contexts.

**METHODOLOGY**

Grounded in the qualitative research approach, the research design chosen for the current study is phenomenography, which uses a naturalistic approach that seeks to understand phenomena in context – specific settings (Patton, 2001). Phenomenography is a qualitative research framework which focuses on understanding perceptions of reality rather than understanding reality itself (Rapley, 2007). The goal of phenomenography is to identify, describe or make statements and assertions about participants’ ideas and experiences (Grix, 2010). The researchers adopted the interpretive paradigm because it enables access to perspectives, knowledge constructions and understandings from inside the meanings of participants and therefore also embody those persons’ contextual meanings. Interpretivist researchers seek to gain access to the developed meanings that participants bring to experiences and that entails the broad cultural and experiential worlds from which those individual’s perspectives and beliefs are formed. Within the interpretivism perspective, researchers tend to gain a deeper understanding of the phenomenon and its complexity in its unique context instead of trying to generalise the base of understanding for the whole population (Pham, 2018).

In this study, these were the developed meanings that school heads, STEM HODs and STEM teachers give through their interpretations of the STEM programme delivery within their schools (Cassel & Symon, 2004).

**Participant Selection**

Participants were five heads of schools (coded as H), five heads of departments (coded as HD) and fifteen STEM subjects’ teachers (coded as T) from five rural day secondary schools in Mashonaland West province of Zimbabwe. The teachers had taught a
variety of STEM subjects which includes Mathematics, Physics, Chemistry and Combined Science at the various schools. The five schools were chosen first on the basis of them offering STEM subjects and thereafter proximity to researchers’ place of work. The participants were purposively selected as they were considered information-rich (Patton, 2002). This strategy of purposeful sampling was used as it was felt that school heads, STEM (HODs) and STEM teachers would have a lot of information on the impact of quality assurance in STEM subjects in rural day secondary schools as they were the ones involved in the teaching and management of these subjects. The Head of the school and the Head of Department of the STEM subjects at each school automatically became part of the sample. Where there were more than three teachers teaching STEM subjects at a particular school, these were stratified according to length of service and the three most experienced selected into the sample on the assumption that their experience would yield rich data for the study.

Data collection and analysis

A semi-structured interview and Focus Group Discussion (FGD) were used to collect data. The focus group discussion was used with teachers because of the large numbers involved while the individual semi-structured interview was used with school heads and heads of departments due the low numbers of these categories of participants. The individual semi-structured interviews were conducted with five heads of schools and five heads of departments constituting a total of ten individual interviews. One focus group composed of three teachers per school from each of the five selected schools was used totalling five focus groups with a total of fifteen teachers. The focus group discussion session solicited information about participants’ experiences of teaching in rural day secondary schools and their experiences and perceptions of challenges of teaching in rural contexts especially the STEM subjects including their views on how these could be mitigated. The interview protocol included similar questions for Heads of Schools and Heads of Departments from a management point of view. The interviews were audio-recorded and then transcribed orthographically, reproducing all spoken words and sounds.

Qualitative research is a broad term encompassing different data collection and analytical approaches with the aim of providing cultural and contextual description and interpretation of social phenomenon (Holloway & Galvin, 2017). In this study the thematic analysis (TA) method of qualitative data analysis was used. Thematic analysis is a method for systematically identifying, organising and offering insight into, patterns of meaning (themes) across a dataset (Patton, 2002). Thematic analysis, therefore, allowed the researchers to see and make sense of collective or shared meanings and experiences. In the

interviews and focus group discussions, participants were all asked about their expectations with regards to quality of STEM subjects teaching as related to the curriculum, class loads, teacher quality. Thematic analysis involved reading through the participants’ responses identifying emerging themes and patterns.

RESULTS AND DISCUSSION

The aggregation of data resulted in the following emerging themes which are presented and discussed in this section; Lack of quality assurance on curriculum design; Lack of supervision and its effect on curriculum implementation; The effect of workloads on effective STEM delivery; The effect of staff shortage on STEM teaching; Lack of knowledge and training in STEM subjects; Negative attitude towards STEM; Teachers demotivated due to the working conditions and that the lack of adequate teaching and learning materials for STEM subjects.

In the responses, the following coding for participants was used: Heads of Schools-H while STEM heads of departments were coded as HD and STEM teachers coded as T. From each of the following themes the first part is a summarised version of the three groups of participants followed by samples of the actual verbatim statements from participants. The third part relates literature to the responses given by participants.

Lack of quality assurance on curriculum design

Participants raised the issue of the content being taught especially with the newly introduced Combined Science as not well organized. Participants’ advocated for a phased in approach starting from Form one arguing that some teachers were not qualified to teach these subjects and this had implications for their ability to develop and correctly interpret the curriculum in this regard. Participants noted lack of staff development in the new STEM subjects they were asked to teach which were not their areas of expertise, for example, Agriculture teachers being asked to teach Combined Science. They argued that there was need for them to be fully involved in curriculum design since they were responsible for the implementation. They had this to say:

H: Due to unavailability of trained teachers for Combined Science those deployed teach topics related to Integrated Science and we end up asking those with these passes at ‗A‘ level to come in and fill the gap.

T: We were just asked to teach Combined Science without any workshop. For example, I am an Agriculture teacher who was teaching Integrated Science.

HD: I am now forced to teach Combined Science. I now have to learn it as I teach students.
The data from the participants points to the need for an incremental approach to implementation of the STEM changes. Participants suggested a phased approach in order to prepare students fully for the STEM subjects. This would also afford teachers enough time to evaluate the implementation phase of the curriculum and hence correct any identified weaknesses.

The purpose of training a secondary school teacher hinges on specialization. Assigning teachers to teach STEM subjects without any training affects both the quality of the curriculum developed and the resulting teaching. Staff development through staff meetings and workshops enriches teachers on the pedagogy of teaching and hence improves their teaching skills. Staff development which is a planned programme that coordinates the need of the individual with the function of the school (Isaac, 2006) should be an integral component of any school. This is in view of the fact that the greatest resource of any school is its staff.

Lack of supervision

Participants raised the issue of supervision as a cornerstone for curriculum implementation. Lack of supervision due to absence of experts in the current School Inspectors at the district offices was seen as a major obstacle to quality assurance. The involvement of school inspectors in supervision is vital to the development of the learning lives of the teachers (Popham, 2005). The issue of lack of expertise could also be seen at school level, where due to lack of expertise on their part, Heads of Schools delegated the supervision process to Heads of Departments. This meant that the Heads of Schools were not playing their supervision roles as expected by the Ministry of Education.

If the researchers are to take the participants’ sentiments from the perspective of systems theory, the focus here was on the interactions and on the relationships between the Heads of Schools and HODs to bring the desired results. A fundamental notion of the systems theory is its focus on interactions. In a school, being an open system, there are exchanges of information amongst staff. Therefore, when discussing quality issues, the link between Total Quality Management (TQM) and Systems Thinking plays a pivotal role as the systemic conception of the school is strengthened by its emphasis on the importance of the relationships of staff to the goals to be achieved. Some participants argued that:

H: Supervision should be the responsibility of the Heads of Department (HODs) especially where we do not have the knowhow of the subject. The Ministry should introduce subject specialists in Districts for better supervision results. Currently at our district education office, there is no single school inspector with a STEM subject qualification.

T: Monitoring by the school Heads is rare. Sometimes you are just called in the Head’s office to sign a lesson report that was never observed. One wonders how the curriculum can be implemented in such a scenario.

HD: Because I am not an expert in all STEM subjects I am sometimes uncomfortable supervising some of the teachers.

From the data given above, it seems the qualifications of schools Inspectors in the District presented some challenges. While all the schools’ Inspectors held a university degree qualification, it was not relevant to STEM subjects which provided some supervisory challenges. This implied that some of their supervisees were better qualified than District Schools Inspectors. It is a truism that a good and effective school is made of good and effective teachers.

The significance of the role of the Head of Department is foregrounded in the findings. The distinct features of HODs would include the ability to get others involved in solving problems; the ability to recognise when a group requires direction, to interact with the group effectively and to guide them to accomplishment of the task (Leithwood, 2020). It is through them that the actual education process takes place, in deed high quality HODs are best resource and asset. The implication of this observation for Heads of Schools should be clear. It is the head of school’s duty to build a team of Heads of Departments (HODs) who are dedicated to their work and contribute effectively to the attainment of their schools’ mission, goals and objectives in regards to STEM education. In delegating the responsibilities to HODs, the Head should consider their ability, specialisation and suitability. He/ she should also show interest in the delegated duties by receiving and considering progress reports from time to time.

It is the responsibility of the school head to monitor and guide curriculum implementation through ensuring that schemes of work, lesson plans and records of marks are prepared regularly. The school head maintains a school tone and culture that creates the climate of social responsibility. Effective curriculum implementation does not take place in a school where the head is incapable of executing supervisory functions (Col, 2000). Failure by the Head of School to execute his/ her duties timeously and professionally affects the quality of STEM education in the schools.

The effect of workloads on effective STEM delivery

Participants indicated the issue of class loads as a factor militating against quality teaching and learning of STEM subjects in rural day secondary schools. Overall, research shows that students in
smaller classes perform better in all subjects and on all assessments when compared to their peers in larger classes (Barrett & Toma, 2013). In smaller classes students tend to be ahead in content knowledge, and score higher on standardised assessments compared to their large classes counterparts. Participants highlighted the need for the Ministry of Education to reduce the teaching load required for a week to acceptable standards. They talked of the need for the authorities to deploy the required number of teachers in schools to curb the shortages. The following sentiments shed light:

**H:** Teachers find it extremely difficult to effectively teach between 40 to 50 lessons per week against a normal teaching load of 30 lessons as the syllabus shows. We cannot do anything unless and until we are adequately staffed.

**T:** Class loads are really a problem in our education system. For example, I have been allocated 40 lessons within a week when under normal circumstances I should have a maximum of 30 lessons. This really kills my enthusiasm to teach.

**HD:** Due to staff shortages, I find myself teaching the same number of lessons with every teacher in the department per week. This leaves me with no supervision time for my colleagues in the department.

Overload in this case affects quality service provision in STEM subjects. When the curriculum is overcrowded teachers will also be less inclined or able to take the time to facilitate active learning activities on STEM subjects. The teaching and learning process as a key component of the systems theory is compromised. Tekleselassie (2019) referred to the “overload” of teachers as forcing them to use classical teacher driven pedagogical approaches in order to manage such unrealistic class loads. Through these approaches, there is more spoon feeding of information to students through taking notes. Little learning takes place and this affects the quality of STEM lesson delivery. Griffith (2010) found a positive association between high academic performance and acceptable class loads and high graduation rates in STEM subjects. A study by Sklar (2014) also reported evidence of strong relationships between class loads and low graduation risk, and suggested the need for institutions to place more emphasis on class loads as they may be contributing factors to STEM switch – outs.

**Lack of knowledge and training in STEM subjects**

A sizeable number of teachers found it difficult to interpret the content in some STEM subjects, for example, Mathematics and Combined Science. The participants highlighted that they were being allocated to teach some STEM lessons for subjects they did not train for at college. This gave them challenges in interpreting the syllabus. They indicated lack of staff development as affecting syllabus interpretation. They had this to say:

**T:** I was trained to teach Economics, now due to shortage of Mathematics teachers I was allocated 12 lessons for Mathematics a week. I have no time to interpret the syllabus content. I go to the matter straight away and teach.

**HD:** I was good at teaching Integrated Science. The Ministry has introduced Combined Science without taking us through staff development or workshops.

From the sentiments above, it is clear that no training was proffered before a change in curriculum to equip the implementers with the correct skills for delivery. Assigning unqualified teachers to teach STEM subjects does not in any way improve the pass rate. Teachers’ knowledge for the subject matter is essential for effective classroom instruction (James and Pollard, 2006). One of the characteristics of good teachers is that they possess a substantial amount of specialized knowledge known as pedagogical content knowledge, which is the intersection between pedagogy and content (Mupa, 2012). Once schools lack teachers with the mechanics of teaching, quality is heavily compromised. The teachers’ attitude is further affected by being forced to teach a subject of not his/her expertise. Chief Education Officer’s circular number 16 of 1993 clearly outlines the expectations placed on educators in order for them to fulfil their role as facilitators of the learning process. Syllabus interpretation is one such key requirement and unless the Public Service Commission unfreezes the deployment of teachers, quality in STEM Education will remain a pipe dream. In many cases, syllabus content interpretation is dependent on critical skills and competency by the teachers involved. In these rural day secondary schools, teachers are assigned to teach subjects in which they have no background training (Sambe, 2015).

Participants were of the view that lack of knowledge and training negatively affected the quality of teaching. The participants argued that there was no replacement of teachers when who went on maternity leave. This was confounded by the fact that government was not replacing those who had transferred. The following indicate the typical sentiments expressed:

**H:** When a teacher is on maternity leave, for example, Mathematics teacher, the school would end up allocating a non-Mathematics teacher to assist the students.

**HD:** Lack of knowledge of the subject affects the teaching as the teacher might have very little to teach.

The observation above is that teachers who have been asked to teach subjects they did not train for at college due to understaffing cannot effectively
deliver on these STEM subjects. The issue of assigning teachers to teach subjects they were not trained for seems to be also prevalent elsewhere. According to Morton et al. (2008), in Finland in 2007, about 30 percent of public middle – school Science teachers taught subjects that they did not major in during college. Among them, 36 percent of Mathematics teachers were not qualified to teach Mathematics. Similarly, in Physics and Chemistry, nearly 30 percent had no certification to teach these subjects.

**Negative attitude towards STEM**

Participants argued that some students had negative attitudes towards some STEM subjects, sometimes due to parental influence. Some students preferred dropping STEM subjects from their lists of subjects to study and only attempting them once they had written and passed the other non-STEM subjects. Due to this lack of interest some school heads could not introduce these STEM subjects at Advanced Level (‘A’ level) at their schools. Advanced Level is the school leaving certificate that prepares students for university in Zimbabwe.

**T:** Some students have negative attitude towards the teaching and learning of STEM subjects and therefore, are passive throughout lesson delivery. Others even play truancy and never attend lessons.

**H:** Some students have openly declared Mathematics as one subject that cannot be passed. They further suggested that they will have to attempt Mathematics when they are done with all other subjects.

**HD:** Some parents do not even want their children to register for STEM subjects as they regard it as a waste of time and money. They prefer that their children attempt STEM subjects after writing all other non-STEM subjects as this may affect their performance overall.

Teachers seem to perceive learners as not being ready and keen to learn the subjects and this affects teachers’ attitude towards students as they enter the classroom. In order to support students to construct their own knowledge and develop an interest in STEM subjects, teachers are expected to display positive attitudes towards the learners. The fact that out of the 5 rural day secondary schools only two offered STEM subjects at ‘A’ Level, confirms the negative attitudes that teachers and heads of schools have towards these subjects. Schools stand guilty as accomplices in aiding would be STEM students to hate STEM education. Studies have shown that attending STEM after-school programs improves attitudes towards STEM fields and careers, increases STEM knowledge and skills, and students have a higher likelihood of graduation and pursuing a STEM career (After school Alliance, 2020).

**Lack of motivation due to poor working conditions**

The findings indicate that teachers lack full commitment to STEM subjects’ delivery which affects quality teaching and learning of the subjects in schools. This lack of commitment was linked to low teacher morale. The withdrawal of the rural allowance that used to be paid to teachers in rural areas as an incentive for teaching under adverse conditions was cited as one of the reasons for low teacher morale. Participants cited accommodation challenges and lack of other resources in rural areas, for example, laboratories that had derailed their zeal to teach. The following sentiments shed light:

**HD:** The government withdrew the rural hardships allowance citing lack of financial resources without consultation.

**T:** Teachers normally want to be role models but look at the house that I am sharing with two others all of us are married. The house has 5 rooms. To worsen matters there are no resources here. We use a classroom for a science laboratory.

The issue of incentives re-instatement is very critical to revive teacher morale and see an improvement of STEM subjects results from rural schools. Teachers need decent accommodation to maintain their status of being role models intact. Schools also need appropriately built science and computer laboratories with adequate materials for use. Dora (2007) argued that people who are depressed have a negative view of their work. This ultimately affects effectiveness and efficiency in lesson delivery in the individual. Findings by (Barley, 2009) suggest that low teacher morale is a result of teachers not prepared for the challenge of rural teaching by both earning the necessary credentials and learning about the nature of working in rural communities. A large part of the rural way of life is managing the social aspects of rural teaching, both within and outside of the school. Individual teachers are a reflection of what they have been surrounded with.

**Lack of STEM subjects’ teaching and learning materials**

Participants highlighted unavailability of teaching and learning materials as a dominant factor that negatively impacted on the quality of teaching and learning of STEM subjects especially with the newly introduced Combined Science. They indicated that WIFI connectivity was not available in their schools. They noted that textbooks were inadequate and that Science laboratories were either unavailable or were ill equipped for the teaching of STEM subjects. They highlighted the following:

**H:** Books are critical due to the fact that they raised teachers’ and students’ knowledge levels. Their unavailability is a cause for worry. Teachers became
the only source of knowledge which becomes worse if they do not have requisite qualifications. What then do we expect students to gain under those circumstances.

**T:** There are no textbooks for students and teachers to use. With non-availability of WIFI to cover the gap it becomes difficult to deliver an effective lesson. We wonder why this subject was introduced in the first place. It was supposed to start with form ones while Integrated Science will be gradually phased out.

**HD:** Combined Science has no textbooks, there is only one textbook for the teacher for the entire two form four classes with more than 90 students set to write the examination this year 2018.

From the discussions through focus groups at these five rural day secondary schools, the pupil textbook ratio, especially for Combined Science and some Mathematics classes was found to be dire. The area of textbooks is a critical area in teaching and learning of STEM subjects. Quality can never be achieved to required standards if schools have not been supplied with the right textbooks. UNESCO (2000) argues that textbooks are effective in raising tests scores in students. It further argues that where there are really no learning materials in schools, virtually no learning takes place. On the same note Mupa and Chabaya (2011) argue that the formula of having someone else read to you from a textbook, does not provide students with the opportunity to understand concepts and learn effectively. The tendency by most teachers is to demonstrate or use one student to demonstrate concepts on the chalkboard to others who just sit in stoic ignorance and sometimes never follow the proceedings.

The research findings underscore the significance of resources in the quality service delivery of STEM education in rural day secondary schools. In practice it is very difficult to teach students in classrooms that lack the necessary resources (Leithwood, 2020). Leithwood (2020) further argues that students’ learning, performance and achievement are highly influenced by the availability of adequate teaching and learning resources. It is argued that education systems that lack the basic educational resources that can make instruction effective and productive face “wholesale systematic decay” (Bush & Oduro, 2006).

**CONCLUSIONS**

From the results of this study, it is clear that more needs to be done to improve the quality of teaching and learning of STEM subjects in rural day secondary schools. It is important to ensure that quality assurance is used as the synergy to provide continuous improvement among heads of schools, HODs and STEM teachers. Quality assurance in this case has to be used to identify areas that need improvement in terms of STEM implementers, curriculum and resources so as to improve service delivery of the STEM programme.

Therefore, the study concluded that firstly, there is a shortage of STEM teachers. What emerged was that there is currently an artificial shortage of STEM teachers as the majority have opted to look for work in the diaspora. Secondly, due to lack of in-service training and professional development in the subjects, for some teachers, there are poor quality teachers teaching STEM subjects. Thirdly, there is a general perception that students shun STEM subjects. Fourth, the learning environment for the STEM subjects is not conducive because of the economic situation in the country. Lastly, there is a dearth of infrastructure that supports STEM subjects. There is shortage of laboratories, equipment, chemicals and other paraphernalia associated with STEM education in rural day secondary schools.

**Recommendations**

Based on the presented data, discussion of findings and conclusions drawn, the following recommendations are put forward for the Ministry of Primary and Secondary Education to consider:

- Most rural day secondary schools still do not have enough laboratories and this adversely affects students’ achievement. There is need to construct these facilities in order to improve the quality of teaching and learning in these schools.
- The study recommends the establishment of STEM centres at relevant levels to assist with easier accessing of information and sharing of STEM experiences. These centres could be at cluster, district or provincial levels.
- There is need to undertake wide stakeholder consultations, advocacy and collaboration on STEM issues in a bottom up approach that will involve the student, the parent/ guardian, teacher, government, industry and other agencies involved in human development on an ongoing basis.
- There is need to fund rural day secondary schools meaningfully if their quality of STEM education is to improve.
- The study recommends the re-introduction of incentives for rural based teachers
- The Public Service Commission is encouraged to unfreeze staff recruitment and deploy correct specialist teachers to rural schools to enhance effective teaching of the subjects.

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