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# Implementing Science, Technology, Engineering and Mathematics Education: A Case of Four Single Sex Secondary Schools in Bulawayo Metropolitan Province, Zimbabwe

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**Abstract**
The purpose of the study was to examine the implementation of STEM education in Bulawayo Metropolitan Province single sex Secondary Schools. This study was qualitative in nature, guided by interpretivist paradigm, and used case study design. The population encompassed seven single sex secondary schools. Participants who included one district schools inspector, four school heads, four heads of departments, sixteen science teachers and forty learners were purposively sampled from four schools. Data were collected through face-to-face semi-structured interviews and focus group discussions, coded and analysed thematically. The results of the study indicated that standard laboratories were available to facilitate the implementation of STEM education in single sex secondary schools. The study further revealed that most of the teachers who taught STEM subjects had relevant qualifications and used various methods to encourage learner participation in STEM education. Additionally, the study established that learners were actively involved in science exhibitions and olympiads which gave learners hands-on experience in STEM subjects. It also emerged from the findings that some female learners are highly confident in taking up STEM subjects and are not afraid to compete against their male counterparts. However, the findings of the study revealed that the implementation of STEM education in single sex schools was constrained by lack of well-equipped science laboratories, lack of financial resources to purchase learning materials, especially chemicals, large class sizes, negative attitude towards STEM subjects by some learners, and limited parental involvement in their children's learning. The study concluded that single sex schools created an enabling environment for learner engagement and afforded both male and female learners equal access to STEM education despite the challenges encountered. The study recommends that the Ministry of Primary and Secondary Education should expedite the construction of well-equipped laboratories and provision of material and financial resources.
**Keywords**: STEM education, STEM subjects, secondary school education, single sex schools, implementation

## 1. Introduction

Worldwide, investing in education has been viewed as a vital step towards producing citizens who can participate in a meaningful manner to national development (Adedeji and Olaniyan, 2011). Thus, the wealth and success of any nation is grounded on its education system. An educational system that is centred exclusively on the basics (reading, writing, and arithmetic) does not concoct future citizens to compete and be successful in the technological world of today and tomorrow (Dugger, 2010). Hence, the mandatory study of Science, Technology, Engineering, and Mathematics (STEM) for all learners in an educational system will afford a more relevant and meaningful preparation for learners in the future (Dugger, 2010; Gadzirayi, Bongo, Ruyimbe, Bhukuvhani and Mucheri, 2016). The main focus of STEM education is to increase the number of learners prepared to enter postsecondary education and pursue careers in the disciplines of Science, Technology, Engineering, and Mathematics (Thomasian, 2011). STEM education is viewed as an interdisciplinary method of learning that allows learners to apply a combination of Science, Technology, Engineering and Mathematics concepts in various scenarios that relate to their every-day experiences at school, in the community, at work, and dealing with globally relevant issues (Tsupros, Kohler and Hallinen, 2009). STEM education's interdisciplinary approach prepares learners for the work-force and gives them practical skills, hands-on experience, and the ability of effectively craft solutions to real-world problems (Ejiwale, 2013). These skills give learners the capacity to promote national and economic development in their countries, thereby boosting the economy and increasing a country's global competitiveness (Parawira, 2016; Australian National STEM Education Strategy, 2015). Thus, considering the crucial nature of STEM education in secondary schools, it is critical to interrogate whether STEM education is effectively implemented in single sex secondary schools.

## 2. Background

Many countries around the world, including global economic powers such as the United States of America (USA) and the European Union (EU) are transforming their education systems to be competitive in the age of innovation (Fensham as cited in Corlu, 2012). According to Dugger (2010) in the past few years, the integration of Science, Technology, Engineering, and Mathematics (STEM) has gained momentum in education in the USA.

The motivation behind this new emphasis on STEM education is to prepare the 21st century workforce by exposing learners to related classroom/ laboratory activities which learners can apply to their future jobs in the real world (Thomasian, 2011; Ejiwale, 2013). A labour force without a rich supply of STEM-skilled individuals will face stagnant or even declining wealth by failing to compete in the global economy, where discovery, innovation, and rapid adaptation are necessary elements for success (Thomasian, 2011). Thus, STEM education heightens the learner's ability to succeed in school and beyond across a wide range of disciplines. The skills acquired through STEM education include, critical thinking to recognize a problem; using mathematics, science, technology, and engineering concepts to evaluate a problem; and correctly identifying the steps needed to solve a problem (Thomasian, 2011). Thomasian (2011) further confirms that research has shown that strong academic preparation in high school improves STEM degree completion rates at universities.

Like developed countries, in recent years, many countries across Sub-Saharan Africa have implemented reforms in their education systems. Though they vary in approach, most of them have focused on strengthening science education. For example, Namibia has experienced major education reforms to improve the quality of science education by encouraging hands-on activities, learner participation, and the use of kits and experiments to demonstrate new ideas to students (Ottevanger, 2001). South Africa has also applied a multi-dimensional approach to improve delivery of science programmes in primary schools, involving the promotion of student-centred learning, providing science kits and learning materials, workshops for teachers, and school-based support (Harvey, 1999). Additionally, Swaziland has focused on improving the teachers' skills and knowledge in science by implementing in-service training programmes where teachers learn new methods and activities, practice these activities, and then return for follow-up feedback sessions after testing them in the classroom (Stronkhorst, 2002). A similar initiative in Botswana had the positive effect of increasing teachers' awareness of the need for change and improvement (Thijs, 1999).

Zimbabwe has also acknowledged the potential of educational reform to equip learners with knowledge, skills and values that guarantee economic growth and increased opportunities for employment creation, well-rounded citizens who are relevant nationally and competitive globally (Mberi and Phambili, 2016). This realization led the Ministry of Primary and Secondary Education (MOPSE) to review and reform the school curriculum in 2014. The reform aimed to improve STEM education at the secondary level by increasing practical learning, and changing from a content-based curriculum to a competency-based curriculum. The programme encourages students who performed well in sciences at Ordinary Level to continue with STEM subjects at Advanced Level (Mberi and Phambili, 2016). These reforms came about in order to increase enrolment in STEM disciplines at the university level, which at the time represented less than 17% of total enrolment (Mberi and Phambili, 2016). Hence, in Zimbabwe, STEM education is offered at almost every academic level, that is, from Early Childhood Development (ECD) up to primary, secondary schools and higher and tertiary education levels (Parawira, 2016).

Remarkably, the STEM revolution in Zimbabwe encourages learners from groups underrepresented in STEM fields, for example, females and learners in rural schools to participate in STEM education (Parawira, 2016). This move is a response to UNESCO (2017) recommendation which states that since girls and women make up 50% of the world's population, there is an urgent need to encourage their participation in STEM fields. UNESCO (2017) calls for governments, specifically Ministries of Education, to formulate favourable policies for fostering girls' participation in STEM disciplines. With that support, more girls would be able to choose, and would feel encouraged to pursue, STEM subjects in schools and in higher education, and would have the right conditions to succeed in STEM alongside boys (UNESCO, 2017).

Despite efforts made by MOPSE in Zimbabwe, some concerns have been raised by educators, learners and other stakeholders that many learners, including female and low achievers, have difficulty in mastering STEM concepts during instructional delivery (Ncube, personal communication, February 12, 2018). Studies have pointed to the abstract nature of STEM concepts as a possible barrier to gaining STEM understanding for all learners (Smith, Rayfield and McKim, 2015). Mabhanda, (2016) laments that despite the teaching of Science and Mathematics in secondary schools learners fear pursuing STEM subjects. He further mentions that the continual lag in STEM education has adverse effects to learners' future employment opportunities. Thus, given the highlighted concerns and observations, there is insignificance evidence on how STEM education is implemented in single sex secondary schools. This, therefore, has ignited the necessity for this study to examine how STEM education is implemented in Bulawayo Metropolitan Province single sex Secondary Schools. Accordingly, it is against this background, that the study sought to respond to the succeeding research questions: (i) How is STEM education implemented in Bulawayo Metropolitan Province single sex Secondary Schools? (ii) What are the challenges experienced by the Bulawayo Metropolitan Province single sex Secondary Schools in implementing STEM education?

## 3. Methods

This study was qualitative in nature and rooted on interpretivist paradigm which basically studies people or

systems by interacting with and observing the participants in their natural settings (Nieuwenhuis, 2007). A case study design which permitted the use of numerous data sources was employed to examine the research questions and gain an in-depth, context specific understanding of the phenomena understudy (Baxter & Jack, 2008). The population comprised seven single sex secondary schools of which four of them were purposively selected as a sample. The sample participants constituted one district schools inspector, four school heads, four heads of departments, sixteen science teachers and forty science learners. Data were collected through face-to-face semi-structured interviews and focus group discussions, and analysed by identifying themes and patterns that emerged from the participants' responses. Credibility and trustworthiness were ensured through use of digital voice recorder which captured research discourses verbatim and triangulation of data from multiple sources (Guba & Lincoln, 2005). As the researchers were conducting the study, they observed the ethical issues of consent, honesty, respect for the integrity of the individual, confidentiality of certain information and anonymity.

## 4. Results

The presentation of the results is based on factors that impact on implementation of STEM education in single sex secondary schools which incorporate infrastructure and resources, teacher training and professional development, learner engagement, learners' attitude towards STEM education, and family involvement. Furthermore, the results on challenges experienced by the single sex secondary schools in implementing STEM education are also presented in this section. The participants are identified as follows: School A to D = four single sex secondary schools, DSI = District Schools Inspector, SHA-SHD = School Heads from schools A-D, HODA-HODD = Heads of Departments, TR1A-TR4D = science teachers, FGD1A to FGD4D = focus groups for science students from four single sex secondary schools.

### *4.1 Infrastructure and Resources*

The participants were asked about the status of infrastructure and resources available which enhance STEM education, the participants indicated that the standard laboratories were available though they needed refurbishment. It also came out from the responses that laboratories needed more apparatus and furniture. The participants further revealed that the ratio of textbooks to learners was not all that bad as in some science subjects is one to two while in other subjects it stood at one to seven. Additionally, the responses indicated that where hard copies of textbooks were inadequate, learners were given soft copies. Examples of participants' responses are as follows:

SHC: *The science labs I believe they are standard. They are measured to 'A' level and 'O' level expectations as far as teaching of sciences is concerned.*

TR2B: *For science it is ok, but it could be better. We have many laboratories, but they need to be renovated, and more apparatus is needed.*

TR3A: *The science laboratories need refurbishment. Some do not have water or electricity. There are not enough stools. They are just old and need total renovations.*

The students also expressed the same sentiments as the teachers. This is what they said:

FGD2B: *Labs are not well equipped. They have some equipment, but there are some apparatus which are not there which are necessary for some experiments, and some chemicals too.*

Regarding the ratio of textbook to learner, this is how some participants responded:

DSI: *Science has been there, it is not a new learning area, so in terms of textbooks I can safely say yes, the ratio is fine, because they have been accumulating over a number of years.*

SHA: *For biology the ratio is one to one. But we must improve other subjects because of the new curriculum. However, science is science, the atom does not change, so old books can still be relevant to new curriculum.*

TR4D: *The ratio used to be okay, but now with the new curriculum we have started afresh procuring textbooks. Now students are sharing one to two. But we also still use the old textbooks.*

FGD1A: *Sometimes we are given soft copies or take pictures with our phones, but that is disadvantage for those who do not have phones or laptops.*

However, some learner participants and HODs felt that the textbooks were not sufficient to enhance the teaching and learning of STEM subjects. This is how some of them responded:

HODB: *We do not have any textbooks tailored for the new curriculum. For upper 6 it is better because the curriculum is mostly the same, but for other forms the curriculum has completely changed, and textbooks do not match at all.*

FGDD: *Textbooks are very few. It is difficult because our teacher does not give us notes, we must write on our own. We are sharing one to five or one to six.*

There is evidence from the participants' responses that the available infrastructure and resources enabled single sex schools to implement STEM education despite some highlighted limiting factors. The provision of soft copies of textbooks to students indicates that some of the single sex schools understudy make an effort to avail essential textbooks to their learners. Such practices enhance the implementation of STEM education.

 

*4.2 Teacher Training and Professional Development*

The teacher participants were asked if they had received any training related to teaching of STEM subjects. The responses indicated that most of the teachers were trained to teach STEM subjects and had Bachelor of Science Degrees. However, some teachers with degrees did not have education qualification, for example, Post Graduate Diploma in Education (PGDE). It came out from participants that those teachers without degrees held diploma in education specialising in STEM subjects. The participants also indicated that teachers with many years of experience in teaching science subjects had no problem in teaching practical lessons, but those teachers without experience struggled to implement practical lessons effectively. Some of the participants further highlighted that they have attended some STEM education workshops and academic conferences whilst others did not attend. Their responses are as follows:

SHD: *Some teachers have academic knowledge but need professional training. They need to complete their PGDE.*

TR2D: *I have not yet done my PGDE. I think about it sometimes, it would really help in terms of classroom management and lesson delivery.*

TR1B: *Some teachers are not really equipped to implement the new STEM curriculum. Some of this has to do with the teacher mastering content, some with the ability of the teacher to do practical lessons. For example, if I do not know how to use burette, how will I teach titration so that learners can learn and write practical exams? Before the new curriculum people would shun the practical side, but now practical experiments are needed.*

With reference to attending workshops and academic conferences, the participants had different opinions which indicate that there are some teachers who benefited professionally from attending conferences while others revealed that they did not gain much. This is what they said:

TR3A: *Over the years I went for workshops while I was teaching 'A' Levels. There are not as many opportunities for junior levels, but for 'A' Levels there are seminars.*

HODA: *Yes, I attended Bindura University Conference three years ago. It was good, enriching, because you get different approaches and share with others.*

However, teacher participant TR3A in dissatisfaction says: *Last year I was at Bindura University Conference, it was okay, but most of the discussions had nothing to do with implementation of STEM at the secondary school level. It was just people presenting their researches. I found it not helpful to teachers.*

The presented data reveal that most of the teachers who taught in selected schools had relevant qualifications to teach STEM subjects though there were a few graduate teachers who did not possess the post graduate diploma in education qualification. The responses also showed that attending academic conferences was fruitful for some teachers while others found it not essential. Basically, it is evident from the participants' responses that the single sex schools under study had teachers with relevant qualifications to implement STEM education.

*4.3 Learner Engagement*

Pertaining to learner engagement, the participants were asked to shed light on how learner participation was encouraged in the teaching and learning of STEM subjects. The responses given by participants showed that teachers used various methods to encourage learner participation which include collaborative learning, assignments based on research activities, group and individual presentations, creating a non-threatening atmosphere where learners are free to learn through mistakes and use incentives such as awards. Examples of participants' views are presented below:

HODB: *I encourage participation through talking, discussions, sharing results and encouraging them to do better. We give awards and prizes for science learners to motivate them.*

TR1B: *I encourage participation through the use of group work, assignments to do research and present to class, class discussions, giving tasks for practical lessons beforehand, and homework.*

HODA: *I am very passionate about my subject. I like creating an atmosphere of enjoyment. Learning should not be threatening, it should be enjoyable. Learners should not view science as a monster or very complicated.*

TR4D: *I keep changing the methods of teaching… one day notes, the next day video, the next day charts.*

TR1A: *We do practical lessons almost every week. I group students for experiments depending on the resources available.*

The learner participants had also this to say:

FGDC: *The teachers are quite good with us, they make us feel comfortable, so it becomes easy for us to talk to them and get clear explanations from them.*

FGDA: *In biology we have a good teacher and he is always encouraging us to participate. He is a great teacher; he always asks if we have questions. It is a good environment to learn in.*

FGDB: *I agree that we have the best mathematics teacher so learning mathematics is really fun. I feel prepared when I go to class and everything we learn I really understand it. It is better than all the other science subjects. Our maths teacher encourages us to work as a team. If she gives us sums and we are quiet she will ask us, "Why are you not talking?" Nothing beats teamwork.*

However, there are some learner participants who had different feelings about learner engagement during the teaching and learning of STEM subjects. Their views are expressed as follows:
FGDD: *We have 27 learners, it is a big number, and many will not participate in class. The teacher will just look at those in the front who are participating without realizing the rest do not understand. As seniors, there is the feeling that if you do not understand you keep quiet because you are afraid of others that if you ask questions they will laugh at you.*
FGDA: *It depends on the teacher. In biology many people participate, but in chemistry not so much. The teacher is harsh, you get scared to contribute because if you say the wrong answer he will beat you.*
The participants were further asked if learners participated in science exhibitions and olympiads. In response, the participants from all four schools mentioned that learners were active in both science exhibitions and olympiads and were doing well. For the instance, some of the evidence from their responses is stated below:
HODC: *Yes, we participate in both Olympiads and Science Exhibitions. Olympiads have not been done well at all, but for science exhibitions we did very well. We participated at an exhibition at NUST and we also participated in another one at Victoria Falls. We have also exhibited at trade fair.*
TR4B: *Yes, the learners participate in science exhibitions and perform quite well. They participate as part of a science club.*
HODB: *Yes, we always do this in all age groups. We compete against mixed schools and boys schools, but what men can do, women can do. Ladies do it with perfection. Saying "girls" is just the sex it has nothing to do with the brains.*
Learners also appreciated the opportunity to attend the science exhibitions and this is what FGDA said: *We work really hard and we believe in ourselves and work as a team, everyone contributes ideas and in the end we come up with something great.*
According to information presented it is evident that learners in single sex schools are exposed to varied instructional methods that enhance learner participation in STEM education though in some cases there are challenges experienced. Most of participants were in consensus that learners were actively involved in science exhibitions and olympiads which gave learners hands-on experience. However, it also emerged from learner participants that their participation in some subjects was hindered by some teachers who used corporal punishment during teaching and learning.

*4.4 Learners' Attitudes towards STEM Education*
As for learners' attitudes towards STEM education, the participants pointed out that the mentally gifted learners had positive attitude towards STEM subjects, whilst other learners pursued STEM subjects because they believed it will lead to better career options, or their parents wanted them to pursue a more prestigious field. The responses also revealed that some female learners are highly positive in taking up sciences and are not afraid to compete against their male counterparts. However, it further came out from the responses that some learners perceived STEM subjects as difficult. The participants gave the following responses:
HODD: *The attitude is positive for some, for others it is negative. For some learners it is not their initiative to take sciences, it is the decision of the parents, so that learner does not have a positive approach.*
TR1D: *The perception is that science is difficult. Which is not true. It comes down to attitude. Most of our boys appreciate sciences, even though results are low. It comes to how teachers are able to motivate their classes. In a boys' high school, it is hard for them to apply themselves fully.*
TR4C: *They have a negative attitude. Many have not registered to write exams. Some parents tell their children to just register the ones they will pass, not to register the ones they are likely to fail.*
TR3B: *Some of our girls are very good, they are even better than boys. They respond very well to questions. But there are some who join simply because it is paid for, and they do not put the effort in, others sleep in class.*
FGDB: *I think for us to be studying STEM it is very motivational for other girls, and helps them get away from the idea that girls are just housewife material. It motivates us to become better people, and it drives us to equality, which is what everyone wants, especially the females. It feels great because there is competition at exhibitions. At exhibitions we compete against schools from across the district, and boys' schools will be there, and our school usually comes first, which shows that we are also good and can do what the boys do.*
FGDD from one of boys' schools confirmed: *I want to discover things, to invent things… There are more job opportunities that pay well… I wanted a highly paying job, but over time I realized that science is interesting. It is inspiring to learn about how scientists have discovered things. I like Maths, Physics and Chemistry and like the challenge of the calculations, I do them because I like the subjects. There are no boundaries, many opportunities, lots of development in the field.*
When participants were asked how the negative attitude and perceptions of some learners towards STEM subjects could be improved, it was indicated that use of role models in society who have done well in the STEM field has been some of the methods that have worked effectively, especially for female learners. Female science teachers can also serve as a positive role models. Their responses are indicated below:

 

HODA: *They fit into stereotypes saying that science is boys' material, so you find that arts classes have more learners than sciences. To combat this stereotype, I try to find girls from this school who are doing well and also refer learners to our alumni in different places such as Mater Dei Hospital, some have done medicine, and others are at National University of Science and Technology (NUST). I want them to look beyond being girls and being at this school knowing they can achieve what those other learners have done.*
TR1C: *I influence a lot. I even used to take them to NUST so that they are inspired. If you look at former learners I taught, most of them are doing exactly what I was saying, following the line I suggested, and they are successful in life.*
TR1D from boys' school said: *I do career guidance with boys, they usually will come to me to consult about their future career. They know I am a science person, some want to be like me. They know we come from the same background.*
The participants were further probed pertaining to those who motivated learners to take up STEM subjects, their responses revealed that most of the female learners cited family members whilst a few of them mentioned influential business or science people, or female role models in their lives such as teachers. In contrast, most of the male learners mentioned well-known business or science personalities as their motivators while a few mentioned family members as their source of inspiration as well. For instance, they responded as follows:
FGDB: *My mom motivates me, she did sciences and she was a doctor, but because of poor health she has retired, so I want to continue for her.*
FGDA: *All the ladies who have done it in the science subjects motivate me. I just wish to be strong like them.*
FGDC: *My motivator is Albert Einstein because as a science student he left us a lot of things in science. Despite Einstein failing his entrance exam, he did not give up and now in history he is one of the greatest minds in science.*
FGDD: *Bill Gates is my inspiration, he gives me the mind that I will also create something in life.*
FGDC: *It is my grandmother who motivated me, she died, but she was looking to the future, she was a civil engineer but died early while giving birth to my mom, so I want to fulfil her dreams.*
Responses from participants showed that most of the learners had positive attitude towards STEM subjects even though there are some few learners who had negative attitude and perceptions. The data presented revealed that use of role models in society who have done well in the STEM field has been some of methods that have worked effectively to encourage positive attitude among learners towards STEM subjects, particularly for female learners. The presented information further indicated that most of the female learners referred to family members as people who motivated them to take up STEM subjects whilst a few of them mentioned prominent business or science people, or female role models in their lives such as teachers. However, most of the male learners identified distinguished business or science personalities as their motivators while a few mentioned family members as their source of encouragement as well.

*4.5 Family involvement*
The participants were asked how the family was involved in their children's learning of STEM subjects in single sex schools. The participants' responses indicated that parents provided learning equipment to support the learning of their children in STEM subjects. However, it was mentioned that in most schools understudy, very few parents attended consultation sessions to discuss the progress of their children with the teachers. The responses from the participants revealed that most parents do not have a strong understanding of STEM education save for those parents who are in the science field at their work places and those enlightened. It was revealed that the rest of parents just push their children to study STEM subjects because they hear it leads to better career opportunities regardless of whether their children showed any aptitude for the sciences. The teacher participants indicated that this leads to negative consequences in learners' learning of STEM subjects. The participants further mentioned that parents have a major influence over the choice of subjects their children should pursue. The following are examples of some of the participants' responses:
SHC: *Yes, parents are involved in their children's learning of STEM subjects. They provide some learning resources for their children such as calculators, stationery, and pay fees and levies.*
HODB: *There are very few who parents who participate effectively. Even on consultation days, some do not come at all even if there is need for them to come.*
FGDC: *For now we have not had consultations this year, but my mother takes time to ask how I am doing in school, if I am having difficulty or if I need crash programmes. My father is a teacher at my school, so he consults every day to all my teachers.*
SHD: *Yes, they do show interest in sciences. At times they believe their children should be studying sciences even if they are not strong in that area. I do not know where we get this impression that everyone should be a scientist.*
HODA: *We face problems because parents do not have knowledge. They all want their students to do science, regardless of whether the child shows aptitude for science or not. Even if we screen at 'O' Level, we still have*

*students who come crying because their mother wants them to take sciences so that she can study medicine.*
HODD: *Some parents do because they are in the science field at their work places, but others just follow because they hear STEM education is good and can lead to a better career path.*
FGDC: *When I tell my parents I am studying sciences they think I am intelligent, most of our parents did not reach 'A' Level, so now they are happy to have their son accomplish what they did not have the opportunity to do.*
Learners also mentioned the following in relation to the influence that their parents have over their career choices. FGDA: *My mom usually encourages me. She even said that if I fail she would punish me. She always asks what I am doing in physics and helps me with my homework, and I like that.*
FGDD: *For me my mom and dad encourage me because I am the first person in my family to do sciences.*
FGDB: *I wanted to do arts, but my mother encouraged me to do sciences, saying I had the potential and passed them before. So I thought hard about it and signed up for sciences, and she was proud of me for picking mathematics.*
Considering the above presented data from the participants' responses, it is evident that the parents are involved in their children's learning nonetheless to a limited extent. The information presented reveal that some parents provide learning materials for their children and also encourage their children to pursue STEM subjects so that they have better career opportunities in future. It further came out from the responses that those parents who are educated had a better understanding of STEM education while those with minimal level of education would just push their children to study STEM subjects despite the learners' aptitude in STEM subjects. Additionally, the responses indicated that some parents attended consultation sessions while others were reluctant to attend.

*4.6 Challenges experienced by single sex secondary schools in implementing STEM education*
With regards to challenges that inhibit the implementation of STEM education in the schools under study, the participants stated that their schools experienced plethora of challenges. These constraints encompassed lack of well-equipped science laboratories, lack of financial resources to purchase learning materials, especially chemicals, and material resources such as textbooks, large class sizes, especially junior and ordinary level classes, negative attitude towards STEM subjects by some learners, limited parental involvement in their children's learning and influence of parents in their children's choice of subjects. Examples of some of the responses from the participants are expressed below:
SHC: *Materials are needed. Using resources from parents alone we will not reach expectations. Science books, gas, and apparatus are expensive. The best books are hard to find and the prices are very inflated. The inflation of prices is a challenge, but this is not unique to our school, but in all of Zimbabwe. Because of the economic situation we end up having very little choices.*
SHD: *Collection of fees is a challenge. We use fees to buy chemicals and equipment, but government came up with policy of not turning away learners who cannot pay fees, and parents are abusing the system. They will not pay fees. Which means we are depriving learners. Everyone suffers, even those who have paid.*
FGDB: *Laboratories are not well equipped. They have what she said, but there are some apparatus which are not there which are necessary for some experiments, and some chemicals too.*
TR1D: *We should do experiments weekly, but we definitely do not do that because of lack of materials. Under normal circumstances, students should do experiments themselves, but often we resort to doing demonstrations.*
FGDA: *There are very few textbooks. It is difficult because our teacher does not give us notes, we must write on our own. We are sharing 1 to 5 or 1 to 6.*
HDB: *We have teachers who have degrees but without pedagogy knowledge, we encourage such teachers who do not have PGDE to upgrade their qualifications, though others face financial constraints.*
HODD: *The attitude of learners is positive for some, for others it is negative. For some learners it is not their initiative to take sciences, it is the decision of the parents, so that learner does not have a positive approach.*
SHA: *In Form 4 we have up to 32 learners, which is very big for practical lessons. 'A' level has 20-25 or 30.*
SHC: *Parents are a challenge. Some just bring their children to school the first time and then forget. Some just come for the first time during consultation, others do not even come. They just come when it is time to collect results. The other problem is that some parents do not have knowledge of STEM education, they all want their children to do STEM subjects despite their children's abilities in sciences.*
The presented participants' responses suggest that the selected schools are not spared from challenges which hinder the effective implementation of STEM education. It has been mentioned that some practical lessons are not properly taught as expected because of lack of well-equipped laboratories. The participants indicated that large class sizes has impacted negatively in the implementation of STEM education in schools under study. It was also revealed that the schools were hard hit by lack of financial resources which derailed the effective implementation of STEM education in selected single sex schools.

## 5. Discussion

The results of the current study revealed that the standard laboratories were available to facilitate the implementation of STEM education in single sex schools though the laboratories needed refurbishment. It also came out from the study that laboratories needed more apparatus and furniture. The findings of this study are commensurate with observation by Ugo and Akpoghol (2016) in Nigeria that most secondary schools lack basic laboratory apparatus, and are inadequately furnished where they exist. The findings of this study further revealed that the ratio of textbooks to learners was average as in some STEM subjects is one to two while in other subjects it stood at one to seven. The results of this study also concur with the National Research Council (2011) which states that schools without the necessary teaching resources and supplies are under-equipped to implement STEM education. However, it emerged from the results of this study that where hard copies of textbooks were inadequate, learners were given soft copies. This was the good practice in enhancing the implementation of STEM education in single sex schools.

The study established that most of the teachers were trained to teach STEM subjects and had Bachelor of Science Degrees and non-graduate teachers held diplomas in education specialising in STEM subjects. Nevertheless, the findings of this study showed that some of the teachers with degrees did not have education qualification, for example, Post Graduate Diploma in Education (PGDE). The findings of the current study are in line with the findings of the study conducted by Mabhanda (2016) in Gweru which revealed that the implementation of STEM education is affected by lack of qualified teachers who have knowledge in the teaching of STEM pedagogical lessons, such teachers do not have training background knowledge that helps learners understand and appreciate STEM education. The results of the study further indicated that teachers with many years of experience in teaching science subjects had no problem in teaching practical lessons, but those teachers without experience struggled to implement practical lessons effectively. It also emerged from the findings of this study that some teachers in selected schools have attended some STEM education workshops and academic conferences whilst others did not attend. The findings of this study further showed that attending academic conferences organised by universities was fruitful for some teachers while others found it not necessary. The results of this study are consistent with what is stated by California Department of Education (2014) that STEM-focused schools embark on research to find innovative methods for structuring the curriculum, develop new instructional techniques and foster connections with the professional STEM community. Thus, STEM education requires teachers to excel in utilizing natural and active exchanges of knowledge, skills, and beliefs among STEM disciplines (Corlu, 2012).

The findings of this study showed that teachers in selected schools used various methods to encourage learner participation which embrace collaborative learning, assignments based on research activities, group and individual presentations, creating a non-threatening atmosphere where learners are free to learn through mistakes and use incentives such as awards. Accordingly, the findings of this study confirm the view that using the project-based learning platform, teachers can encourage all learners, both girls and boys, to perform challenging tasks. The teacher should encourage girls and boys to engage in the projects that interest them or that focus on their areas of interest. Given equal opportunities to build on their individual areas of interest, girls and boys are likely to discover exciting and challenging projects that will be relevant to their interests (UNESCO, 2017).

It was further found that learners were actively involved in science exhibitions and olympiads which gave learners hands-on experience in STEM subjects. This finding is in accordance with what is contained in literature that one way to motivate learners and cultivate learner interest in STEM subjects is to offer various extracurricular activities to learners which include afterschool enrichment activities, science fairs or Olympiads, and other competitions (California Department of Education, 2014). However, it also emerged from study that learners' participation in some STEM subjects was hindered by some teachers who used corporal punishment during teaching and learning process. Such use of reactive methods by teachers are in violation of the children's rights enshrined in the Constitution of Zimbabwe, 2013: Chapter 2 Article 2.11 which states that children should be protected from maltreatment, neglect or any form of abuse (Sibanda and Mpofu, 2017). Accordingly, the prevalence of unsupportive learning climate is not conducive to nurture the learners' zeal to participate in STEM subjects (Mabhanda, 2016).

The study established that mentally gifted learners had positive attitude towards STEM subjects, whilst other learners pursued STEM subjects because they believed it will lead to better career options, or their parents wanted them to pursue a more prestigious field. The results of the study also revealed that some female learners are highly confident in taking up STEM subjects and are not afraid to compete against their male counterparts. This finding is in agreement with observation by some scholars that single sex schools may provide better environments for female learners with regard to both teacher-learner and peer-group interactions, which may encourage them to pursue their educational careers in STEM education as well as improve female learners' overall educational outcomes. The female learners develop self-concept, self-efficacy and confidence in STEM subjects (Park, Behrman and Choi, 2011). Conversely, it further came out from the findings that some learners perceived STEM subjects as difficult. This study confirms what has been observed by Parawira (2016) that at

 

secondary school level STEM subjects become more rigorous and challenging, learner awareness of STEM fields and occupations is still pursued, as well as the academic requirements of such fields.

The results of this study revealed that use of role models in society who have done well in the STEM field has been some of methods that have worked effectively to encourage positive attitude among learners towards STEM subjects, particularly for female learners. Thus, the findings of the current study aligns with comment by UNESCO (2017) that gender-responsive teachers in STEM education understand and respond to the specific needs of girls and boys throughout the teaching and learning process to help ensure that all learners, girls and boys, are able to fulfil their potential in STEM education.

The findings of the study further indicated that most of the female learners referred to family members as people who motivated them to take up STEM subjects whilst a few of them mentioned prominent business or science people, or female role models in their lives such as teachers. On the other hand, the results of the study revealed that most of the male learners identified distinguished business or science personalities as their motivators while a few mentioned family members as their source of inspiration as well. The results of the current study are consistent with the view that gender stereotypes are believed to influence both the aspirations and achievements of boys and girls in the fields of science, technology, engineering, and mathematics (AlSindi, 2013).

The findings of this study indicated that parents provided learning equipment to support the learning of their children in STEM subjects. However, it emerged from the findings that in most schools understudy, very few parents attended consultation sessions to discuss the progress of their children with the teachers. It further came out from the findings that those parents who are educated had a better understanding of STEM education while those with minimal level of education would just push their children to study STEM subjects despite the learners' aptitude in STEM subjects, because of the lucrative nature of STEM careers. The results of the study further indicated that parents have a major influence over the choice of subjects their children should pursue. The results of this study affirm what is suggested by literature that there is a need to increase awareness among parents and learners concerning the importance of STEM education (California Department of Education, 2014). The influence of parents in choosing subjects for their children also emerged in the study by Mabhanda (2016) in Gweru that learners do not want to take up STEM subjects because of the attitude inherited in families and society.

The study found that the selected schools experienced plethora of challenges which encompassed lack of well-equipped science laboratories, lack of financial resources to purchase learning materials, especially chemicals, and human resources to teach some of STEM subjects, large class sizes, especially junior and ordinary level classes, negative attitude towards STEM subjects by some learners, limited parental involvement in their children's learning and influence of parents in their children's choice of subjects. It emerged from the findings of this study that some practical lessons are not properly taught as expected because of lack of well-equipped laboratories. This finding upholds Chitate's (2016) view that the teaching of the natural sciences is, especially hampered by the apparent lack of basic laboratory equipment, in both the new and old schools. The study found that large class sizes has impacted negatively in the implementation of STEM education in schools under study. The results of this study support what has been found in literature that large class size denies learners the opportunity to get the attention they require from the teacher for effective learning, they get frustrated and discouraged. Such class sizes contribute to low performance in Science, Technology, Engineering and Mathematics subjects. Furthermore, when there are large class sizes the weak students tend to hide under the cover of the mentally gifted ones (Ugo and Akpoghol, 2016).

It was also revealed in this study that the staffing of graduate teachers without pedagogy qualification derailed the effective implementation of STEM education in selected single sex schools. The finding of this study endorses what is mentioned by California Department of Education (2014) that even if the importance of STEM learning has been widely acknowledged, several factors have limited access to STEM education. Such factors involve insufficient focus on science as well as on STEM education in the classroom; lack of access to high-quality STEM materials and instruction; insufficient opportunities for learners to engage in hands-on, inquiry based learning; and insufficient professional preparation by teachers at all levels.

## 6. Conclusion

The study examined how STEM education is implemented in Bulawayo Metropolitan Province single sex Secondary Schools. The study established that standard laboratories were available to facilitate the implementation of STEM education in single sex secondary schools. It was revealed by the study that where hard copies of textbooks were inadequate, learners were given soft copies. It came out from the study that most of the teachers who taught STEM subjects had relevant qualifications and they used various methods to encourage learner participation in STEM education. The study established that learners were actively involved in science exhibitions and olympiads which gave learners hands-on experience in STEM subjects. The results of the study indicated that some female learners are highly confident in taking up STEM subjects and are not afraid

 

to compete against their male counterparts. The study revealed that single sex secondary schools were not spared from constraints which hampered implementation of STEM education. The challenges encompassed lack of well-equipped science laboratories, lack of financial resources to purchase learning materials, especially chemicals, large class sizes, negative attitude towards STEM subjects by some learners, and limited parental involvement in their children's learning. Regardless of the constraints experienced by single sex schools, the study concludes that there were some good practices in the implementation of STEM education, such as creating an enabling environment for learner engagement and affording both male and female learners equal access to STEM education. The study recommends that the Ministry of Primary and Secondary Education should expedite the construction of well-equipped laboratories and provision of material and financial resources. The study further recommends that another study with a larger sample, using mixed methods approach, should be conducted in rural co-educational secondary schools to get an insight of how STEM education is implemented in rural schools.

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