Science Teachers’ Awareness of and Responses to Science, Technology, Engineering & Mathematics Teaching and Learning in Zimbabwe

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A project submitted to the department of Educational Foundations, Faculty of Science Education, Bindura University of Science Education, Bindura, Zimbabwe, in partial fulfillment of the requirements of the Postgraduate Diploma in Science Education.

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APPROVAL FORM

I, Dr. Vongai Mpofu, undersigned, certify that I have read this project entitled: Science Teachers’ Awareness and Responses to STEM Teaching and Learning in Zimbabwe, conducted by Artwell Chibowora, Registration number B1543569 in partial fulfillment of the Postgraduate Diploma in Science Education. I further approve its submission and recommend to Bindura University of Science Education for it to be examined.

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Date Signed
DECLARATION

I, Artwell Chibowora, Registration Number, B1543569 do hereby declare that this project has been as a result of my own unaided work and investigations and such work has not been presented elsewhere for the purposes of project assessment. Additional sources of information have been acknowledged by way of referencing. It is being submitted for the Postgraduate Diploma in Science Education in the Department of Educational Foundations, Faculty of Science Education of the Bindura University of Science Education

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ABSTRACT

This study sought to establish how conscious science teachers are about STEM curriculum reform in Zimbabwe. Specifically, it focussed on their understanding of STEM teaching - learning, their responses to the STEM teaching and learning initiative, and why teachers responded to the initiative in the manner they did. The research adopted a descriptive cross-sectional survey, situated in the qualitative research paradigm. Forty three (43) teachers selected from five high schools in Mashonaland East Province participated in this study. The data that was generated through a Likert Scale Questionnaire and a Semi Structured Interview guide was qualitative content analysed. It emerged from the study that (1) teachers held diversified views of what STEM teaching and learning entails, (2) there are mixed responses by the participating teachers towards STEM teaching and learning and (3) their reactions are negatively inclined towards the STEM curriculum. The study concluded that (1) a significant number of science teachers are not aware of what it entails to implement the new curriculum, (2) a significant number of science teachers have not changed their classroom practices and (3) most had no access to resources, such as a guiding framework to implement the new curriculum. The study recommends that teachers need further training and more resources need to be provided in the form of well-equipped science laboratories, relevant textbooks, materials for use in project work and there is also need to create strategic partnerships with industries so that their needs are in tandem with what pupils are being taught in schools.
DEDICATION

This research is dedicated to my wife Zanele, son Ronald and my effervescent daughter Faraimose.
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LIST OF ABBREVIATIONS

CIE Cambridge International Examinations
CIET Commission of Enquiry into Education and Training
MHSTESD Ministry of Higher and Tertiary Education, Science and Technology
MOPSE Ministry of Primary and Secondary Education
NGO Non-Governmental Organization
PCK Pedagogical Content Knowledge
STEM Science, Technology, Engineering & Mathematics
UNICEF United Nations Children's Fund
ZIMDEF Zimbabwe Manpower Development Fund
ZIMSEC Zimbabwe School Examinations Council
CHAPTER ONE: AN INTRODUCTION TO THE STUDY

1.0 INTRODUCTION

The Government of Zimbabwe has begun aggressively pursuing the integration of Science, Technology, Engineering and Mathematics (STEM) education into the mainstream curriculum, across the three main educational levels, primary, high and tertiary. The STEM concept in education is being actively pursued by many nations, developed and developing. The government of Zimbabwe hopes that STEM graduates will emerge to be critical thinkers and problem solvers who will create practical solutions to current and upcoming problems (Gandawa, 2016). However, teachers who are expected to implement this curriculum innovation at classroom level may be challenged or unaware of its existence or receive it differently. Whatever the case maybe, these possibilities challenge those who are into research to find out the teachers’ standpoint on this task. This chapter introduces this study. It contains several components which form its organisation: background to the study, the problem statement, research questions, objectives, and the significance of the study, its assumptions, delimitations and limitations. The chapter ends with a summary.

1.1 BACKGROUND TO THE STUDY

In Zimbabwe, when pupils get to high school, they are required to study eight subjects on average. They then write an examination after four years, leading to the attainment of a General Ordinary (‘O’) Level certificate. The subjects studied are a combination of the Sciences, Humanities and Commercials. At Advanced (‘A’) Level, pupils are required to choose three subjects and if they pass them, they are awarded an ‘A’ Level certificate and may proceed to tertiary level. Tertiary education in Zimbabwe relates to any type of education pursued beyond the high school level. This includes diplomas, undergraduate and graduate certificates, and associate, bachelors, masters’ and doctoral degrees (Learn.org, 2017). However, the colonial education system adopted by the Zimbabwean government was castigated by many Zimbabwean stakeholders as irrelevant to its cultural and socio-economic needs. This prompted, in 1998, the then President of the Republic of Zimbabwe, Robert Mugabe, to appoint a Commission of Inquiry into Education and Training (CIET) to look into the status of the education system and what could be done to make it relevant to the national needs. The
commission concluded that the then curriculum was outdated and only catered for a few academically gifted pupils. The commission made several recommendations.

Based on these recommendations, the government of Zimbabwe has now implemented a new curriculum at primary and secondary school levels, starting January 2017. Prior to that, in January 2016, the government, through the Ministry of Higher and Tertiary Education, Science and Technology Development (MHTESTD) and the Zimbabwe Manpower Development Trust (ZIMDEF), launched the ‘A’ Level STEM initiative which ‘seeks to encourage students who sat for their ‘O’ Level examinations in 2015 and obtained a Grade ‘C’ or better in Mathematics, Biology, Physics and Chemistry to take a combination of these STEM related subjects at ‘A’ Level (Lower Sixth) in 2016’ (ZIMDEF, 2016). The mantra: ‘Stemitise, Industrialise, Modernise the curriculum’, has since been adopted. The idea behind the STEM initiative is to train and develop cutting edge skills that will meet the human capital needs of Zimbabwe’s quest for industrialisation and modernisation (Staff, 2017). National universities and colleges have been urged by the government to embrace the STEM initiative and a lot of resources are going to be needed to make the programme a success. Lecturers and science teachers are critical components of the process, as without them, the country will be unable to ‘stemitise’. A study such as this one that focuses on teachers as key components of the programme is therefore justified.

STEM has become government policy in leading industrialised nations such as the United States of America. Most countries in Europe as well as China, Australia, Korea, Taiwan are paying more attention to STEM teaching (Baran, 2016). The Southern African Development Community (SADC) has produced ‘a draft Regional Industrialisation Strategy and Roadmap that provides a framework for major economic and technological transformations at the national and regional levels within the context of deepening regional integration’ (Ngwawi, 2015). The primary focus of this strategy is the ultimate attainment of industrialisation, regional integration and economic competitiveness (Ngwawi, 2015). In Zimbabwe, the need to industrialise is there for all to see. The country finds itself in an economic quagmire with industry capacity utilisation currently at less than 50% (Mhlanga, 2016). Most industries are now stuck with obsolete and antiquated equipment. A research such as this one is important as it will go a long way towards the realisation of the STEM objectives.

In Zimbabwe, when pupils get to high school, science subjects (Biology, Chemistry and Physics) are traditionally taught separately, with learners being equipped with the theoretical
knowledge to pass examinations. Douglas (2016), notes that there is little, if any, linking of teaching of these subjects to solving real world problems involving critical thinking on the part of learners. He further states that, whilst employers value subject knowledge, they are placing a much higher premium on the need for soft skills to sit alongside that subject. STEM integration offers students one of the best opportunities to experience learning in a real world situation, rather than to learn bits and pieces and then to have to assimilate them at a later time (Wang, 2011). Teachers therefore need to be prepared to change the way they conduct lessons if STEM is to be a success, hence their preparedness needs to be looked into.

From the foregoing discussion, it is clear that industrialised countries have invested heavily in STEM teaching and continue to do so as they seek to remain major players in the world economy. Zimbabwe is therefore moving in the right direction as it seeks to emulate these nations. Since the STEM initiative is still in its infancy, policy makers will need all the relevant information they can get so that nothing is left to chance. A study of this nature will go a long way by helping policy makers in identifying how teachers can be brought on board by looking at areas such as pre-service and in-service teacher training, looking for strategic partners such as industrialists, Non governmental organisations (NGOs) etc.

1.2 THE PROBLEM

The problem that drove this study is stated in three interrelated ways: (1) its statement, (2) research questions breaking down the problem into manageable units, and (3), the research objectives providing a focused purpose of the study.

1.2.1 Statement of the problem

Most science teachers may be aware of the acronym STEM, but it is doubtful whether they understand what it entails to integrate it into their teaching. The reality is that it is ‘business as usual’ in the classroom. The teaching of STEM subjects remains theoretical with no real effort in exposing pupils to real life situations. This scenario may be due to a number of reasons such as limited knowledge on the part of the teachers. In this case, ‘knowledge’ includes STEM subject content, integration pedagogy and assessment of learning. A teacher who was trained to teach in the traditional way will find it very difficult to adapt to the unfolding reality of having to ‘stemitise’. Traditional teaching is concerned with the teacher being the controller of the learning environment. Power and responsibility are held by the teacher and they play the role of instructor (in the form of lectures) and decision maker (Novak, 1998). To make matters
worse, these teachers have not been given clear guidelines on what content to teach, how to teach it and assess learning progress. Teachers’ limited knowledge of what is currently happening in industries is also a contributory factor. For example, a Biology teacher may never have seen the machinery used to make yoghurt, ice-cream or beer. Similarly, some Physics teachers have never seen an ultra sound scanning machine used at local hospitals. Teachers are confronted with lack of teaching resources and laboratories to carry out effective teaching. If these factors are not solved, they will have a direct bearing on the success of the STEM initiative.

This research therefore seeks to find answers to the research questions (RQ) stated below:

**RQ 1:** How conscious are science teachers about STEM curriculum reform in Zimbabwe?

**RQ 2:** How are these teachers responding to the STEM teaching and learning reform?

**RQ 3:** Why do teachers respond the way they do to the STEM teaching and learning reform?

To be more focused, the above research questions were translated to the following research objectives (RO):

**RO 1:** To determine level of consciousness of science teachers with regards to STEM curriculum reform in Zimbabwe.

**RO 2:** To describe how science teachers’ are responding to STEM teaching and learning.

**RO 3:** To explain why teachers respond the way they do to the STEM teaching and learning reform.

### 1.3 SIGNIFICANCE OF THE STUDY

The essence of the study is to gain an understanding of science teachers’ consciousness and responses to the STEM initiative. The implementation of the programme heavily relies on the classroom practitioners as they will be expected to lay the foundation and inculcate the necessary skills expected to be possessed by STEM graduates. The government will spend a lot of money in implementing STEM and as they craft the relevant policies for the success of
the programme, they will need the vital information from studies such as this one. The information from the study may also be useful to non-governmental organisations (NGOs) such as the United Nations Children’s Fund (UNICEF) who are interested in educational issues. The information may guide them on how they may intervene in areas such as the provision of necessary STEM skills and funding further education for aspiring as well as practising teachers.

The decision to accelerate industrialisation in Zimbabwe is certainly the right one. Successful economies like China have invested heavily in industries and the results are there for all to see. The success of the STEM initiative justifies the researcher’s interest in this area.

1.4 ASSUMPTIONS OF THE STUDY

It was assumed that: selected participants would share their knowledge in an honest and candid manner, would be available at the agreed times to enable the researcher to finish the study within the projected time frame. The resources needed for the study would be available. For example, stationery, printing facilities as well as funds to cover transport costs.

1.5 STUDY DELIMITATION

This study is delimited in three ways discussed below.

1.5.1 Setting

The study setting is Marondera District in Mashonaland East province located in Eastern Zimbabwe. The participants are from five high schools which, for the sake of preserving their anonymity are given pseudonyms as (i) Green Eagle High school, (ii) Maple Hills High School (iii) Sun Valley high school (iv) Golden Arrow high school and (v) Northfield high school.

The first two schools are run privately whilst the other three are government schools. The three government schools were selected because they already have some pupils who have been sponsored by government to study STEM related subjects. The two private schools also have some school leavers who opt to attend local universities and therefore might benefit from the STEM initiative.
1.5.2 Key terms

Three main constructs: (1) curriculum reform awareness, (2) curriculum reform responses and (3) STEM teaching and learning are discussed. These are, later in Chapter Two, related into a conceptual framework.

1.5.2.1 Curriculum reform awareness (CRA)

The term CRA is three words compounded. Its meaning as used in this study is derived from the combined meanings of these words. Firstly, curriculum means a selection from the culture of society, of aspects which are so valuable that their survival is not left to chance, but is entrusted to teachers for expert transmission to the young (Lawton, 1975). Secondly, to reform is to make changes in something, (especially an institution or practice) in order to improve it (Oxford, 2017). Last and thirdly, awareness means knowledge that something exists, or understanding of a situation at the present time based on information or experience (Cambridge, 2017). CRA, in the context of this study, can therefore be deduced to mean the knowledge, on the part of teachers, of the difference between teaching science subjects in the traditional way and implementing the new STEM curriculum.

1.5.2.2 Curriculum reform response (CRR)

CRR also consists of three words: curriculum, reform and response. The first two terms have been defined in the previous section whilst response refers to an answer or reaction to something. In this study, CRR entails looking at how high school teachers have responded to the recently introduced curriculum on STEM teaching and learning.

1.5.2.3 STEM teaching and learning

STEM is a curriculum based on the idea of educating students in four specific disciplines — science, technology, engineering and mathematics. Teaching can be defined as the process of attending to people’s needs, experiences and feelings, and making specific interventions to help them learn particular things. Teachers therefore impart knowledge to or instruct (someone) as to how to do something; or cause (someone) to learn or understand something by example (Smith, 2016). Learning, on the other hand is the act of acquiring new, or modifying and reinforcing existing knowledge, behaviours, skills, values or preferences which may lead to a potential change in synthesizing information, depth of the knowledge, attitude or behaviour relative to the type and range of experience (Krueger, 2017).
But, the meaning of the construct, STEM teaching and learning, is twofold: the separatist and integration. The separatist perspective frames STEM as the teaching of STEM related subjects as separate, discrete and disconnected. Teaching each subject separately is seen to be easier as subject experts concentrate on their subjects and help pupils in creativity, problem solving, generating their own questions, thereby developing a mind of being inquisitive (Australian Department of Education, 2015). The integration approach frames STEM as integrating STEM related subjects into a cohesive learning paradigm based on real-world applications (Hom, 2014). In other words, it an interdisciplinary and trans-disciplinary approach to learning, wherein academic concepts are coupled with real-world problem-based learning (Gurukula, 2017).

1.5.2.4 Methodology

A cross sectional survey (CSS), which is situated in the qualitative research paradigm was the methodology adopted. Within this methodology data was generated through a Likert Scale questionnaire and Semi Structured interviews. The questionnaire data was descriptive statistics analysed whilst the interview data was content qualitative analysed.

1.6 LIMITATIONS OF THE STUDY

Science teachers at the five schools mentioned in section 1.1.2 above were targeted for this research but for various reasons, not all of them could take part. When it was time to collect questionnaire forms from the participants, some of them requested for more time to complete them but this was not possible as the researcher had deadlines to meet. This had the effect of reducing the target population size.

The issue of time also affected interviews. Fewer teachers were eventually interviewed. This was so that there would be enough time to analyse their responses.

Access to some journals on the internet was not possible as these required one to be subscribed in order to be allowed to read them.
1.7 CHAPTER SUMMARY AND ORGANISATION OF THE STUDY

This chapter introduced this study. It has presented the background information and the rationale for undertaking the study. It has been noted that the government of Zimbabwe is going ‘full steam ahead’ in implementing the STEM initiative. It has also been mentioned that it will need all the support it can get and the results of this research maybe a source of valuable information in the crafting of policies needed to make STEM teaching and learning a success. Chapter two discusses the literature related to this study which was reviewed. Chapter 3 discusses the methodology used whilst chapter 4 discusses results and findings of the study. The study is concluded by a summary, conclusion and recommendations in Chapter Five.
CHAPTER TWO: LITERATURE REVIEW

2.0 INTRODUCTION

This chapter takes a look at the STEM literature related to this study that was reviewed. Literature review entails taking a survey of the current knowledge including substantive findings, as well as theoretical and methodological contributions to a particular topic (Lamb, 2016). Literature review is done, among other reasons, to identify potential areas for research, identifying knowledge gaps that demand further investigation and to identify similar work done within the area (University of Reading, 2012). The chapter situated this study in literature with four main components: (i) recent reforms to the science curriculum in schools, (ii) STEM education in Zimbabwe, (iii) the concept of STEM teaching and learning and, (iv) a possible learning and response awareness conceptual framework with regards to STEM teaching. These four themes form the organisation of the chapter. The chapter is concluded with a summary which highlights the main points discussed and introduces the next chapter.

2.1 STEM CURRICULUM REFORMS

Many nations have put programmes in place to promote the teaching of STEM subjects in schools. This has seen science curricula in these countries taking a dramatic shift towards promoting the teaching of the subjects. For example, some of the major reforms in STEM education in the United States of America (USA) include Science for all Americans, the Young Naturalist Awards, Systemic Reform, National Science Education Standards Project, Scope Sequence and Coordination, Architectural Construction and Engineering (ACE) Mentor Programme, Race To The Top (RTTT) and Educate to Innovate (Okpala, 2011). This section will now look at some of the reasons advanced to promote STEM teaching and learning and what is now trending in different parts of the world with regards to reforming the STEM curriculum.

Traditionally, science subjects have been taught (and pupils learnt them) separately. This type of learning entails scouring chapters of textbook, defining terms in the glossary, and highlighting pertinent sections. There would be an occasional demonstration or class
discussion, and then it would be test time (Krueger, 2017). STEM education, on the other hand, integrates concepts that are usually taught as separate subjects in different classes and emphasizes the application of knowledge to real-life situations. A lesson or unit in a STEM class is typically based around finding a solution to a real-world problem and tends to emphasize project-based learning (Bouchillon, 2017).

According to Murray Correy (2013), there are several reasons why STEM education should be prioritised. These include the following: 80% of the fastest growing occupations in the USA depend upon the mastery of mathematics and scientific knowledge and skills. Workers who hold STEM degrees enjoy higher earnings regardless of occupation. According to Amanda Roberts (2012), in 2008, China and India together produced 700 000 engineers. She says this is significant because it is the engineering and technological fields that help drive the economy. Innovation and invention are influential forces in the economy and these skills cannot be developed apart from an education system that prepares students to fulfil these demands.

Governments around the world are spending a significant amount of money from their budgets to go towards the funding of STEM education. In Wales in the United Kingdom, the minister of education declared that ‘the importance of our children and young people developing STEM skills are essential to the development of a prosperous and sustainable knowledge economy’ (Government, 2015). In Hong Kong, the Curriculum Development Council has stressed the need for STEM teaching to enhance ‘the capabilities required to fulfil the needs of economic, scientific and technological developments in the contemporary world’ (Education Bureau, 2016). In Australia, in 2015, the government spent twelve million dollars to restore focus and increase student uptake of STEM subjects in primary and secondary schools (Australian Department of Education, 2015).

Although African countries are behind their counterparts in the rest of the world, in terms of implementation, a significant number of them have begun making strides in pursuing STEM education. Megan Ivy (2015) reports that regions all over Africa are promoting STEM education to help bolster their economies. She further writes that the World Bank, in 2014, approved financing for 19 university based centres of excellence in countries in West and central Africa. These countries include Nigeria, Ghana, Senegal, Benin, Cameroon, Togo and Burkina Faso.
In Zimbabwe, the government is aggressively pursuing the promotion of STEM teaching and learning. In 2016, it was announced that free education would be provided for STEM pupils. Those who were accepted into the programme were entered into a competition and they ‘stand a chance to win a trip of a lifetime to Microsoft and other Silicon Valley STEM companies in the United States of America (there will be ten winners) or a state-of-the-art laptop (one hundred winners) or state-of-the-art iPad (one hundred winners)’ (Zhakata, 2016).

From what has been discussed above, a number of countries in Africa and beyond have realised the importance of teaching STEM subjects as it has been shown that this will make their economies competitive on the global stage. Zimbabwe is thus following in the footsteps of huge and successful economies such as that of China who have realised benefits of investing in equipping leaners with STEM skills. The next section will look at STEM education in Zimbabwe.

2.2 STEM EDUCATION IN ZIMBABWE

This section focuses on the status of STEM education in Zimbabwe. The section also touches on some of the challenges that the country has encountered so far.

There is not much research, focusing on STEM education in Zimbabwe that has so far been done. This is understandable as the Government only started aggressively pursuing the STEM initiative in 2016. However, some research papers have been published. Chirume (2016) in the study on Mathematics teachers’ perceptions and implementation levels of STEM education in their classrooms in Gweru District, Zimbabwe concludes that the Zimbabwe government should come up with a clear policy on STEM education, STEM monitoring and evaluation. There is a general consensus among Zimbabweans that the initiative is the way to go although there are some who remain sceptical. One industrialist summed up the scepticism when he said; “The major problem here in Zimbabwe is lack of focus. Today there is much noise about STEM but come two years down the line, this will be history. No one will be talking about this”. (Gadzirayi, 2016)

The introduction of STEM teaching and learning is relatively new in Zimbabwe with most teachers teaching science subjects the traditional way. In addition there is a shortage of these teachers. Expectedly, ‘stemitizing’ and indigenizing classroom science as a reform agenda creates challenges mainly because the current state of teachers’ pedagogical content knowledge (PCK) does not support effective integration and is an impediment to science curriculum
implementation; which is an affront to the realization of envisaged goals of STEM education reform. For this reason, in-service teacher professional development programs targeting scaffolding teachers’ developing PCK specific to STEM teaching should be encouraged (Mpofu 2017).

The implementation of the STEM initiative in Zimbabwe faces a number of challenges. The Financial Gazette (2016), reports that the shortage of teaching resources and qualified science teachers has been one of the programme’s Achilles’ heels. This has been caused by a number of factors, chief among them poor remuneration, leading to a brain drain as teachers leave to look for greener pastures abroad. The government is cash strapped and does not have enough funds to fully implement the programme. Zhou, T (2016) puts it bluntly and says: ‘the Obama administration’s 2014 budget invested 3.1 billion dollars in federal programmes on STEM, yet we are naive to expect success from a zero budget’. He was referring to the amount of money spent by the USA on STEM education. Zimbabwe also does not seem to have teachers qualified to teach the disciplines. The majority were trained to teach the subjects separately using traditional methods. This section has therefore highlighted the fact that STEM education in Zimbabwe is still very much in its infancy and faces a number of challenges. The next section will look at what constitutes STEM teaching and learning.

2.3 INTEGRATED STEM TEACHING AND LEARNING (ISTEML)

This section discusses the different models of ISTEML. As discussed in chapter 1, the integration approach is one of the two main approaches to STEM teaching and learning.

Teaching can be defined as the process of attending to people’s needs, experiences and feelings, and making specific interventions to help them learn particular things. Teachers therefore impart knowledge to or instruct (someone) as to how to do something; or cause (someone) to learn or understand something by example (Smith, 2016). Learning, on the other hand is the act of acquiring new or modifying and reinforcing existing, knowledge, behaviours, skills, values, or preferences which may lead to a potential change in synthesizing information, depth of the knowledge, attitude or behaviour relative to the type and range of experience (Krueger, 2017).

While there has been considerable research in recent years on how to improve teaching and learning in science, technology, engineering, and mathematics individually, there has been relatively little attention to how, and to what degree, the four individual subject areas might be
integrated for the purposes of enhancing teaching and learning, what the challenges to such integration might be, and what impacts on learning, motivation, and other desirable outcomes might result (Heil, 2013).

In Zimbabwe, Mpofu and Vhurumuku (2017) argue that the cultural and indigenous knowledge of learners can be harnessed and used in the teaching of science in schools. For example, the skills that are required to play a popular African game (the peddle game) can be used by teachers to illustrate scientific concepts. The beauty of this example is that teachers can extract skills used in the game and use them to draw comparisons when explaining concepts in disciplines such as Biology, Chemistry and Physics.

In Minnesota, in the USA, a study was done to see how teachers were using integration in their work (Wang, 2011). One of the teachers tasked her class to design a package to carry fragile glass panels across continents in land vehicles or ships. The design required pupils to use their knowledge from each of the STEM subjects. The science component of the project required inquiry on the part of the pupils. The mathematical component was problem solving, whilst the engineering component focused on the engineering cycle which is: ‘imagine, plan, create, improve’ (Wang, 2011). In trying to enhance STEM teaching, the government of Turkey in 2014 funded a training programme for teachers and pupils. Some of the activities that pupils were required to undertake included designing a package that would keep an egg inside from breaking when it was dropped from the 4th floor of a building. The best design was selected by analysing the status of the eggs. The package and the egg simulated space vehicles that would land on Mars safely without harming astronauts on board (Baran, 2016). All of the challenges required pupils to draw on the knowledge from the STEM subjects.

This section has thus highlighted the relationships that exist between teaching and learning as well as what it means to teach STEM subjects. It has also been highlighted that the teaching of STEM subjects is already being practised elsewhere as exemplified by what is happening in USA and Turkey. Teaching STEM subject requires innovation but it must be pointed out that there is no one correct way of doing it. The key to creating engaging STEM activities is the proper design and implementation of an effective ‘integrating’, problem-based activity. This provides the context for student’s learning and enables the meaningful integration of knowledge into a solution or product that demonstrates student’s learning across the different domains of STEM. (Berry, 2016)
2.4 STEM TEACHING - LEARNING AWARENESS - RESPONSE

In this section, a diagram has been used to depict the STEM teaching, learning awareness response conceptual framework. In this framework the role of the teacher is explained and shown to be the critical component that underpins the success of STEM teaching and implementation in schools. The section also touches on alternative responses by teachers to the new curriculum.

The conceptual diagram shown above illustrates the various components that interact to make STEM teaching and learning a success. Once the curriculum has been developed, the teacher, who has been trained in the appropriate pedagogies, puts it into action. He/she then prepares pupils so that they attain skills required for them to participate meaningfully in industry and become useful citizens in the community. Curriculum content and expected classroom pedagogy are developed with the needs of the community in mind.

In integrated STEM teaching and learning, the teacher is expected to coordinate and manage activities and projects that can be applied within and across science and mathematics that illustrate a variety of inter-disciplinary and subject-specific models of STEM learning (Gurukula, 2017).

The teacher is regarded as the key agent of change in the curriculum implementation process since he/she prepares the lesson and teaches to impart knowledge on the students. He/she is also the one to give feedback to the policy makers (Atomatofa, 2013).

The diagram above shows that the teacher is the central and critical component of the implementation programme. The teacher here is seen to be handling all the requirements of STEM teaching and learning. It should be pointed out that there are different ways of teaching.
STEM subjects. According to the Australian Department of Education (2015), it is possible for a teacher to teach a specific discipline separately to enhance concept development. The department further says that technology, maths and science teachers can design a combined unit and each teacher teaches different components of the unit in their separate subject, and with clear contributions from science, maths and technology subjects in solving a common problem.

Perspectives on how discipline integration can be achieved are varied, with reference to multidisciplinary, interdisciplinary, and transdisciplinary approaches adding to the debates (Hom, 2014). However, all the approaches are housed in a common theme; producing critical thinkers with problem solving skills.

2.5 CHAPTER SUMMARY

This chapter has highlighted the literature that was reviewed during the course of this study. The chapter has four main sections. The first section looked at science curriculum reforms worldwide, reforms in Africa and our own science curriculum reforms in Zimbabwe. The second section deals with STEM education in Zimbabwe by looking at the rationale behind implementing the programme and the challenges being faced. The third section looked at the different approaches that can be used to teach STEM subjects. The fourth section looks at the learning awareness and response conceptual framework with regards to STEM teaching and learning. The next chapter will look at the research methodology that was employed.
CHAPTER THREE: RESEARCH METHODOLOGY

3.0 INTRODUCTION

This chapter takes a look at the different aspects of research methodology that were used during the research. Methodology is the philosophical framework within which the research is conducted or the foundation upon which the research is based (Brown, 2006). This chapter has seven main components: (i) research context, (ii) research design, (iii) participants (iv) research authority (v) data collection tools, (vi) methods of analysing data and (vii) presenting and reporting findings. These seven themes thus form the organisation of the chapter. The chapter is concluded with a summary which highlights the main points discussed and introduces chapter four.

3.1 RESEARCH CONTEXT

In this section, a description of the location of the schools from which participants were drawn will be given. The section also covers the characteristics of the schools in terms of the curriculum they follow and some of the reasons why these schools were selected for this study.

3.1.1 Geographical location

This study was carried out with participants drawn from five schools around Marondera town, the capital of Mashonaland East province. The schools, whose names (pseudonyms) are listed in section 1.5, are again listed below for quick and easy reference. These are Green Eagle, Maple Hills, Sun Valley, Golden Arrow, and Northfield high schools.

The five schools were selected, firstly because they are closer to where the researcher resides. They are easily accessible as they are serviced by good roads and to reach them, one can cycle, drive or use public transport. This made it more convenient and cheaper to liaise with relevant authorities as well as administer questionnaires for the research. Secondly, the schools offer STEM related subjects and the participants, as experienced classroom practitioners, were deemed to be in a position to answer questions used to generate research data.

The first two schools listed above are independent (private) schools whilst the other three are government schools. According to the Zimbabwe Education Act of 2001, government high
schools in Zimbabwe are under the jurisdiction of the Ministry of Primary and Secondary Education (MoPSE). According to their 2017 website, the ministry formulates and implements policies on education structure, curriculum, pedagogy, and assessment, and they oversee the management and running of all schools in the country. The ministry runs the schools via Provincial and District offices. The majority of teachers at these schools are employed by the government through the Public Service Commission and a few may be employed by School Development Associations.

In a broad sense, a private school is any formal school that is outside the public education system (Igor, 1999). The Education Act of 2001 further states that all private schools must be registered with MoPSE. Whilst the schools are regulated by the ministry, they do not necessarily follow the government prescribed curriculum.

3.1.2 Curricula of targeted schools

In Zimbabwe, government schools get their curriculum from the Ministry of Primary and Secondary Education. After a four year period of study at high school, pupils write the ‘O’ Level examination which is set and marked by the Zimbabwe Schools Examination Council (ZIMSEC). Those who are successful proceed to study ‘A’ Level subjects and at the end of two years, they write an examination which is again set and marked by ZIMSEC. After ‘A’ levels, pupils proceed to a vocational technical college, a teachers’ college or university. Those that do not wish to enrol into senior secondary may choose to enrol for tertiary education in institutions such as Teachers’ Colleges, Polytechnic colleges, Agricultural colleges and Vocational and Training colleges. Most pupils from government high schools further their education in Zimbabwe (Zimstat, 2013). Pupils who attend government schools are mainly from the low and middle classes of society. According to government policy, the teacher pupil ratio at high schools is one teacher to thirty five pupils per class (Mawonde, 2016). The curriculum policy requires pupils in high school to do seven compulsory subjects at ‘O’ level; which are Maths, English Language, General Science, Indigenous Languages, Agriculture, Physical Education, Sport and Mass Display and Heritage Studies (Gambanga, 2017)

Students who wish to write more than this can select from a list that includes subjects like Computer Science, Geography, Physics, Chemistry, Biology, Additional Mathematics, Pure Mathematics, Statistics, History, Commerce, Economics, Principles of Accounts, Design and

The majority of private schools in Zimbabwe have a system of education similar to that of government schools but they write examinations that are set and marked by Cambridge International Examinations (CIE). A few private schools offer both the CIE and ZIMSEC curricula. Pupils who attend private schools are mainly from the middle to upper classes of Zimbabwean society (Kawadza, 2014). Information provided by headmasters at the private schools from which participants were drawn indicates that the teacher pupil ratio at these institutions is around one teacher to fifteen pupils. At the end of ‘A’ levels, most pupils from private schools proceed to universities outside the country whilst a few enrol at local universities. At the private schools that were used for this study, the core subjects at ‘O’ level are Accounting, Mathematics, English, Science, Geography, and History. The other subjects are French, Literature in English, Biology, Physics and Chemistry. At ‘A’ level, pupils choose to study the sciences, commercial subjects or the Arts subjects.

3.2 RESEARCH DESIGN

There are three main paradigms in which educational research designs are grounded: quantitative, qualitative and mixed. The quantitative approach uses measurement as the most precise and universally accepted method for assigning quantitative values to the characteristics or properties of objects or events for the purpose of discovering relationships between variables under study (Pandian & Muthamizhselvan, 2017). Barratt and Kirwan (2009) define qualitative research as a type of social science research that collects and works with non-numerical data and that seeks to interpret meaning from these data that help us understand social life through the study of targeted populations or places. The authors further assert that the CSS design entails analyzing data collected from a population, or a representative subset, at a specific point in time; that is, cross-sectional data. The term “mixed methods” refers to an emergent methodology of research that advances the systematic integration, or “mixing,” of quantitative and qualitative data within a single investigation or sustained program of inquiry (Wisdom & Cresswell, 2013).

This research adopted a cross-sectional survey (CSS) situated in the qualitative research paradigm. Barratt and Kirwan (2009) define qualitative research as a type of social science research that collects and works with non-numerical data and that seeks to interpret meaning.
from these data that help us understand social life through the study of targeted populations or places. The authors further assert that the CSS design entails analyzing data collected from a population, or a representative subset, at a specific point in time; that is, cross-sectional data. Some of the advantages of cross-sectional studies that made me adopt them is they are not costly to perform and do not require a lot of time (Rivers, 2017).

This research seeks to determine how conscious science teachers are about the STEM curriculum and how they are responding to it. Non-numerical data was generated during the study and when this was processed, it gave insights into the teacher’s views and their responses (or lack thereof) with regards to STEM teaching and learning.

3.3 PARTICIPANTS

This section describes the participants and the criteria used in selecting them. It also describes the sampling method that was used to select them for the research.

The total number of science teachers in the targeted schools was fifty seven. The researcher was satisfied that this was a manageable number so all the science teachers in the five schools became participants. Thus a census was used. Census refers to a complete enumeration of a universe. A universe may be a place, a group of people or a specific locality through which we collect the data (Farook, 2013). Using the characteristics specified in the conceptual framework shown in section 2.4 above, all the participants are qualified teachers and had experience in teaching STEM related subjects so they were deemed to be ideal candidates to give insights into the research questions.

Table 3.1 below shows the number of science teachers at each of the five schools and the STEM related subjects offered at each school at ‘O’ and ‘A’ level.

Table 3-1: Number of science teachers, enrolment and subjects offered at targeted schools

<table>
<thead>
<tr>
<th>School</th>
<th>Enrolment</th>
<th>Number of Science teachers</th>
<th>STEM related subjects offered at ‘O’ level</th>
<th>STEM related subjects offered at ‘A’ level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The teachers who teach the subjects that are listed in the table above were targeted and given questionnaires to complete.

3.4 RESEARCH AUTHORITY

Seeking research authority for access to participants is in line with ethical considerations in doing research. To uphold these ethical standards, the researcher sought and obtained authority from various levels of the Ministry of Primary and Secondary Education (MoPSE). These were at: Provincial Education Office, District Education Office, schools and science departments.

Initially, the researcher obtained a letter of introduction from Bindura University of Science Education (BUSE) (see Appendix 1). The letter of introduction was attached to application letters that sought permission to conduct this research. The proforma application letter is shown in Appendix 2. The province of Mashonaland East, District of Marondera and the five schools granted me authority as evidenced in appendices 3, 4 and 5 respectively.

3.5 DATA GENERATION

This section describes sources of data collected, tools used, nature of data generated and how the data was analysed. This is summarised in the table below.

<table>
<thead>
<tr>
<th>School</th>
<th>Number</th>
<th>Male</th>
<th>Female</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Eagle</td>
<td>845</td>
<td>4</td>
<td>8</td>
<td>Computer Science, Geography, Physics, Chemistry, Biology, Mathematics</td>
</tr>
<tr>
<td>Maple Hills</td>
<td>900</td>
<td>6</td>
<td>4</td>
<td>Maths, Biology, Chemistry, Maths, Physics, Geography, Computing</td>
</tr>
<tr>
<td>Sun Valley</td>
<td>700</td>
<td>7</td>
<td>5</td>
<td>Computer Science, Geography, Physics, Chemistry, Biology, Mathematics</td>
</tr>
<tr>
<td>Golden Arrow</td>
<td>600</td>
<td>9</td>
<td>3</td>
<td>Maths, Biology, Chemistry, Physics, Geography, ICT</td>
</tr>
<tr>
<td>Northfield</td>
<td>450</td>
<td>8</td>
<td>5</td>
<td>Computer Science, Geography, Physics, Chemistry, Biology, Mathematics</td>
</tr>
</tbody>
</table>

Table 3-2: Data sources, generation methods and analysis
The data generation components shown in table 3-2 above are explained in more detail in the ensuing sections.

### 3.5.1 Data source

Table 3-2 above shows that science teachers at the schools listed in Table 3-1, section 3.1 were the source of the data that was generated. The participants were all practising science teachers whose work experience ranged from five to more than fifteen years. They could therefore be relied upon to provide authentic information that could be used to answer the research questions.

### 3.5.2 Data generation methods

As Table 3-2 is showing, two methods of generating data were adopted. These are the Likert scale questionnaire (Appendix 6) and a semi-structured interview guide (Appendix 7).

#### 3.5.2.1 Likert Scale Questionnaire (LSQ)

A questionnaire is a data collection instrument in the form of document that contains a systematically compiled and well organised series of questions intended to elicit the information which will provide insight into the nature of the problem under study (Annum, 2017). Of the many types of questionnaires available in literature, this study adopted a LSQ. A Likert scale is a psychological measurement device that is used to gauge attitudes, values, and
opinions. It functions by having a person complete a questionnaire that requires them to indicate the extent to which they agree or disagree with a series of statements (Williams, 2017).

The self-developed LSQ (see Appendix 6) is in three sections. The first section solicited background information of the participants such as teaching experience, age, type of school etc. Section two contains statements that solicited the participants’ awareness on STEM teaching and learning. Section three solicited the participants’ responses to STEM teaching and learning.

The questions that are on the LSQ were carefully crafted so that they could be used to answer the research questions stated in Section 1.2. In developing the questions, the curriculum framework illustrated in Section 2.4 was also used as a reference point. To test the usability of the questions, peers were asked to go through them and give constructive criticism with regards to any ambiguities that might have been present. Finally the supervisor endorsed the questionnaire as fit to be used in the field to gather data.

3.5.2.2 **Semi structured interviews (SSI)**

In addition to the LSQ used to solicit for data from participants, a semi structured interview (SSI) guide was also used to further obtain more information from selected participants.

A semi-structured interview is a qualitative method of inquiry that combines a pre-determined set of open questions (questions that prompt discussion) with the opportunity for the interviewer to explore particular themes or responses further, but lines of enquiry will be pursued within the interview, to follow up on interesting and unexpected avenues that emerge (Blandford, 2013).

The SSI guide (Appendix 7) used in this study has three sections. The first section shows session details such as date and time as well as where the interview was held with each respective participant. The second section has the questions that were posed to the interviewees. The questions were designed in such a way that they enabled the researcher to get further insight into answers given by participants in the LSQ. The questions enabled the interviewees to shed more light into their understanding of STEM teaching and learning, pedagogical and assessment methods required by the new curriculum. The third section was designed to allow participants to air their views and comments regarding STEM teaching and learning.
3.5.3 Data generating and capturing procedures

This section shows the timeline on how data was collected from participants in the field. It also summarizes the procedure used in collecting data.

Table 3-3 gives a timeline on how the questionnaire was administered at the targeted schools.

Table 3-3: Data generation and capturing schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 Feb</td>
<td>60 questionnaires printed</td>
<td>All printed</td>
</tr>
<tr>
<td>13 Feb</td>
<td>Golden Arrow teachers complete forms</td>
<td>Forms completed and handed in to researcher</td>
</tr>
<tr>
<td>14 Feb</td>
<td>Visit to Sun Valley</td>
<td>Some forms completed. Some teachers request for more time to complete</td>
</tr>
<tr>
<td>15 Feb</td>
<td>Handing out of questionnaires at Northfield, Maple Hills &amp; Green Eagle</td>
<td>Forms completed. Teachers at Green Eagle request for more time</td>
</tr>
<tr>
<td>18 Feb</td>
<td>Collection of questionnaires from Sun Valley</td>
<td>Task of collecting all questionnaires completed</td>
</tr>
<tr>
<td>10 March</td>
<td>Analysis of results</td>
<td>Gone through process of analysing results with supervisor</td>
</tr>
<tr>
<td>7 April</td>
<td>Development of SSI guide</td>
<td>Process done and completed</td>
</tr>
<tr>
<td>9-13 April</td>
<td>Interviews</td>
<td>Five participants took part</td>
</tr>
</tbody>
</table>

3.5.3.1 Questionnaire administration

At each school, the researcher approached the Head’s office and introduced himself and the purpose of his visit. Upon showing the Head the letter of introduction from BUSE and letters of authority from the Provincial and District offices, he was referred to the science departments
where he explained the purpose of his visit to the head of department. The Head or head of department would then stamp the authorization letter (Appendix 3) to authenticate that teachers at that particular school had taken part in the study. The head of department introduced him to potential participants (science teachers). The researcher would then explain the purpose of his visit, sought voluntary consent and request teachers to sign the participation consent form (see sample in appendix 8). The signing of consent forms upheld the ethical consideration of voluntary consent (Trochim, 2006). This was followed up by handing out questionnaires and consent forms for completion.

3.5.3.2 Interview sessions

After the analysis of questionnaire data, five (5) participants were purposefully sampled for interviews. Purposive sampling is a sampling technique in which the researcher relies on his or her own judgment when choosing members of a population to participate in the study (Dudovskiy, 2017). Interview sessions were conducted in two main stages as discussed below.

Appointments were made with selected participants and the interviews took place over a four day period.

The first stage involved making preparations for the interviews. Potential interviewees were contacted telephonically whilst others were contacted via the social medium, Whatsapp. The purpose of the interview was explained to them and they were assured that their participation remained confidential and that they were free to either decline to take part or they could withdraw at any time. This is in keeping with the upholding of ethical standards in carrying out research.

The second stage involved the actual interview process. Participants were given the option of choosing the venue where they felt safe and comfortable. Upon meeting with each participant, pleasantries were exchanged and again the purpose of the interview was explained and the importance of honesty in giving answers was underscored. After this building of rapport, permission was sought from each participant to record the interview. The recording of the interviews was done with the aid of a Samsung mobile smart phone. During the interview process, probing questions were sometimes asked to seek clarification on points raised. Finally participants were asked to make comments and/or ask questions.
3.5.4 Nature of data generated

Responses to questions on the questionnaire were in the form of ticks in the appropriate boxes. Semi-structured interviews generated text data in the form of field notes and audio recordings.

3.5.5 Analysis of Likert scale questionnaire data

Participants responded to forty three questions on STEM teaching and learning on the LSQ. Analysis of the LSQ data was done in phases as discussed below.

3.5.5.1 Phase 1: identification of participants by pseudonyms

Pseudonyms were return on each completed questionnaire.

3.5.5.2 Phase 2: Establishment of the response and questionnaire completion rates

This is calculated as the number of returned questionnaires divided by the total number of questionnaires initially handed out (Fincharm, 2008).

Table 3-4 Information used to calculate response rate

<table>
<thead>
<tr>
<th>Number of targeted science teachers</th>
<th>Number of questionnaires given out</th>
<th>Number of returned questionnaires</th>
<th>Return rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>57</td>
<td>57</td>
<td>43</td>
<td>75</td>
</tr>
</tbody>
</table>

Response Rate = Total of items given out /Total items returned x 100 = 43/57 x 100 = 75%

Establishment of completion involved checking whether all questions had been responded to. This was done by going through each question in the completed questionnaires and using a highlighter to mark questions that were not completed. The number of teachers that were targeted in this research was fifty seven. Out of these, forty three filled in the questionnaires and returned them, giving a response rate of seventy five percent. Of the remaining fourteen, one returned the questionnaire with only the background section completed. This was discarded as it had insufficient information. Five claimed they had misplaced the questionnaires whilst the rest decided to voluntarily withdraw from participating citing pressure of work.
After going through all the papers from the respondents, the completion rate was calculated and found to be nearly one hundred percent. Table 3-5 below shows the information that was used to calculate completion rate.

Table 3-4: Information used to calculate completion rate

<table>
<thead>
<tr>
<th>School</th>
<th>Participants</th>
<th>Incomplete items</th>
<th>Total number of items</th>
<th>Total number of complete items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northfield</td>
<td>10</td>
<td>3</td>
<td>310</td>
<td>307</td>
</tr>
<tr>
<td>Golden Arrow</td>
<td>12</td>
<td>0</td>
<td>362</td>
<td>362</td>
</tr>
<tr>
<td>Maple Hills</td>
<td>4</td>
<td>0</td>
<td>124</td>
<td>124</td>
</tr>
<tr>
<td>Green Eagle</td>
<td>5</td>
<td>0</td>
<td>155</td>
<td>155</td>
</tr>
<tr>
<td>Sun Valley</td>
<td>12</td>
<td>0</td>
<td>362</td>
<td>362</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>43</strong></td>
<td><strong>3</strong></td>
<td><strong>1006</strong></td>
<td><strong>1003</strong></td>
</tr>
</tbody>
</table>

The three incomplete items were from 10, 12, and 16 from Ms Moyo, Ms Dube and Ms Sibanda respectively.

\[
\text{Completion Rate} = \frac{\text{Total of completed items}}{\text{Expected total}} \times 100 \\
= \frac{1003}{1006} \times 100 \\
= 99.7\%
\]

3.5.5.3 Phase 3: Coding

Coding is the process of perusing through data for categories and meanings (themes, ideas, etc.) and then systematically marking similar strings of text with a code label. (Graham, 2007). Each LSQ item was analysed and rephrased into units of analysis. A unit of analysis is the major entity that you are analyzing in your study. (Trochim, 2006). These units of analysis were further analysed and grouped according to similar meaning.

Six broad categories which emerged from this analytic exercise are: (1) Teacher Knowledge of STEM teaching and learning, (2) Teacher Capacitation to implement the STEM curriculum (3) Teaching approaches adopted by teachers (4) Teachers’ accessibility to STEM teaching and learning resources (5) Teachers’ views on the successful implementation of the STEM initiative, and (6) Assessment approaches adopted by teachers.
The first category, Teacher Knowledge of STEM teaching and learning measured the participants’ understanding of STEM teaching and learning. Second, the Teacher Capacitation sought to determine whether science teachers have been trained to implement the STEM curriculum. Thirdly, Teaching Approaches sought to determine whether teachers are still using traditional methods of delivering lessons or they had embraced methods aligned to STEM teaching and learning. The next category, Teachers’ accessibility, was to find out if teachers had access to materials such as magazines and information from the internet to enable them to implement the STEM curriculum. The fifth category, Views on Success was to gauge the teachers’ views on whether they thought the STEM initiative would succeed or not. The last category was to find out the assessment approaches currently being used by teachers; whether they are still stuck with traditional assessment methods or whether they had aligned to STEM methods.

Each category embraced two codes that related to either the participant’s agreed or disagreed with each Likert scale item as shown in Figure 3-1 below.
3.5.5.4 Phase 4: Descriptive statistics analysis

Descriptive statistics gives numerical and graphic procedures to summarise a collection of data in a clear and understandable way (Jaggi, 2011).

Using the Descriptive Statistical Analysis (DSA) approach, identical responses were counted and then expressed as a percentage. These values were then depicted on either a bar graph or a pie chart. Graphs and charts allowed the researcher to get a visual image of the observations, which simplified interpretation and drawing of conclusions.
3.5.6 CONTENT QUALITATIVE ANALYSIS OF SSI DATA

During the interviews participants responded to seven open ended questions on STEM teaching and learning. The analysis of data generated from interviews was done in stages as discusses below:

Stage 1: This involved identification of units of analysis. A unit of analysis is a word, sentence, paragraph or entire text from which we draw meaning in relation to the study problem and research questions.

Stage 2: This involved coding units of analysis, which means deriving meaning from the units of analysis.

From the interview responses, meaning was ascribed to seven different components of STEM teaching and learning, which are (1) understanding of STEM teaching and learning, (2) teaching approaches, (3) content that ought to be taught, (4) assessment methods required, (5) inclusion of STEM concepts in lessons, (6) demands placed on the teacher and (7) views on success if STEM initiative. The meanings are discussed under the appropriate headings in Chapter four.

3.6 PRESENTING AND REPORTING FINDINGS

The products of data analysis are research findings which are presented and discussed in the ensuing chapter four. Findings from LSQ data are presented in form of tables or figures (bar graphs and pie charts) generated using Microsoft Excel. The choice of using tables and graphs for data presentation is because of their ability to clearly classify different data. They are used to organise information to show patterns and relationships. (Joyce, Neill, Watson, & Fisher, 2008). These pictorial presentations are interpreted and integrated with findings from SSI data and semi structured interviews in written English. Findings from SSI data are presented in descriptive form, including verbatim quotations under the relevant headings in the next chapter.

3.6.1 SUMMARY OF THE CHAPTER

This chapter has highlighted the major components of research methodology. The first section described the research context. This was followed by the discussion of the research design section including the paradigm in which it is grounded. The description of science teachers as participants of this study including how they were sampled and their characteristics then
followed. How research authority was obtained and how other research ethics were upheld are also discussed. To follow in the discussion were methods of generating, recording and analysing data. The chapter wrapped up with the discussion on how findings will be presented and discussed in the coming chapter four. The next chapter will look at findings and their discussion.
CHAPTER 4: PRESENTATION AND DISCUSSION OF FINDINGS

4.0 INTRODUCTION

This chapter presents and discusses findings relating to teachers’ responses and awareness to STEM teaching and learning in Zimbabwe. This study sought to answer three questions, which are:

**RQ1:** How conscious are science teachers about STEM curriculum reform in Zimbabwe?

**RQ 2:** How are these teachers responding to the STEM teaching and learning reform?

**RQ3:** Why do teachers respond the way they do to the STEM teaching and learning reform?

The answers to these questions form the organisation of the chapter. These are (1) Teachers’ awareness to STEM teaching and learning, (2) Teachers’ responses to the STEM Teaching and learning curriculum and (3) Reasons underpinning their responses to the STEM Teaching and learning curriculum. The chapter ends with a summary and an introduction to the next chapter.

4.1 TEACHERS’ UNDERSTANDING OF STEM TEACHING AND LEARNING

As depicted in Figure 4-1 below, teachers held diversified views of what STEM teaching and learning entails. These understandings fell into eleven groups.
Figure 4-1: Teacher knowledge of STEM teaching and Learning

The Teacher knowledge of STEM teaching and learning understandings categories are presented and discussed in turn below.

4.1.1 STEM as an acronym

Ninety eight percent (98%) of the participants had an understanding of STEM as an acronym irrespective of their varying backgrounds (i.e. age, gender, teaching qualifications etc). This understanding was enhancing during interviews as exemplified in the following excerpt:

STEM teaching and learning is all about embracing science, technology, engineering, mathematics in the teaching and learning process (Mr. Zuva, April, 2018).

This finding is not surprising because in response to the introduction of the STEM curriculum in Zimbabwe, the Ministry of Primary and Secondary Education in Zimbabwe launched the Teacher Capacity Development Programme (TCD). The TCD programme targeted to train about 5000 teachers in STEM by the end of 2015 (Gadzirayi, 2016). Since then the term STEM has become a buzz word published in local media. For instance there were awareness programmes hosted by various media houses including radio stations, television stations, newspapers as well as information posted on the internet by government departments such as Zimbabwe Manpower Development Fund.
However, the understanding of STEM as an acronym is quite narrow and shallow since STEM teaching and learning in a more sensible and fruitful way means the an integrated pedagogy that combines teaching and learning of two or more of the STEM subject areas as well as non-science subjects offered in schools (Sanders, 2009).

Teachers’ understanding of the meaning of STEM places them in good stead to implement the curriculum. This understanding means that the teachers are aware that in the course of delivering lessons within the new curriculum, it will no longer be business as usual meaning that a shift in the way they conduct lessons is required.

4.1.2 STEM Education as Teaching and learning of STEM subject related concepts

The survey results revealed that ninety three percent (93%) of the teachers who participated in this study also hold an understanding of STEM education as the teaching of STEM related subject concepts such as Physics, Biology, and Chemistry etc. This is supported by results from the interviews where two main approaches were suggested by the participating teachers. These approaches are (1) practical work with a bias towards solving real life problems and (2) teaching content from all the STEM subjects.

Those who believe that STEM teaching and learning should involve practical work made statements such as:

practical concepts that involve problem solving such as developing applications and theory concepts about Computers and ICT in general must be taught( Mr. Mari, April 2018)

Those who agree that teaching of STEM must be integrative made statements such as the following:

when you are teaching Maths, there should be some scientific, technological, engineering aspects in the idea of teaching Maths.

The integration approach to STEM education is in agreement with scholars like, Hom (2014) who say that STEM is a curriculum based on the idea of educating students in four specific disciplines of science, technology, engineering and mathematics in an interdisciplinary and applied approach. This is a shift from the discipline and separatist approach of teaching STEM related subjects in that it demands the teachers to integrate concepts from other STEM related subjects into their teaching of the science subject as well relate to real-world applications.
The majority of the teachers, therefore, are aware that the new curriculum demands teaching that incorporate concepts scientific disciplines content which relate to real life problems and possible solutions. As Parawira (2016) says, STEM teaching and learning prepares students for a lifetime of innovation and exploration and it plays an increasingly important role in addressing critical needs of society and generating innovation that drives the global economy.

4.1.3 A new pedagogical approach

The results revealed that sixty seven percent (67%) of the participants understood that the STEM curriculum demands a shift to a new pedagogical approach. The interview results concur with the teachers’ understanding that STEM teaching and learning is a shift from the traditional and separatist approach to the teaching of STEM related subject to new pedagogical approaches. Two main stem teaching and learning approaches emerged from the interviews. These are (1) real life problem solving approaches and (2) integrated approaches. In relation to real life problem solving approaches Mr Mari said:

STEM is Science, Technology, Engineering and Mathematics Education and its focus is on developing pupils who are future problem solvers, pupils who are able to apply theoretical knowledge to real life practical situations and in the process enhance entrepreneurship, encourage innovation and improve economics

Those who brought out the understanding of STEM teaching and learning as an integrated pedagogy were revealed by such expressions as:

an interdisciplinary and applied approach to teaching and learning where Science, Technology, Engineering and Mathematics subjects are taught collectively rather than teach the four disciplines as separate and discrete subjects (Mr. Zama, April 2018).

To support this finding agrees are scholars like Joyce and Dzoga (2011) who assert that STEM education is an emerging pedagogy which involves moving student-centred approaches that brings together a variety of proven motivating pedagogies such as inquiry-based learning, problem-solving and collaborative work is required. Other scholars describe this pedagogy as STEM integrated (Mpofu & Vhurumuku, 2017). This is a shift from traditional teaching methods. These STEM pedagogies are important to adopt because STEM Education is the foundation for Science and technology careers. It is science and technology that drives economic transformation of any nation. In Zimbabwe this stipulated in the Zimasset.
Notably, the survey brings out that only 67% of the participating teachers held the understanding of STEM teaching and learning as a new pedagogical approach. It is worrisome that the remaining thirty three percent (33%) were for the idea that traditional pedagogical approaches could be used to implement the new curriculum. It can be drawn from this finding that such teachers are not aware what STEM teaching and learning pedagogically entails. They still are holding on to traditional and separatist pedagogies. Scholars like Joyce and Dzoga (2011) provide a possible explanation to this finding. Such scholars say STEM concepts are not always easy to grasp – particularly when dealing with dynamic concepts that cannot easily be illustrated in a textbook. It could also be explained in terms of resistance to curriculum change. Embracing change is cognitively demanding. As such, this could be the underpinning various reasons that include, lack or resources, limited content to teach, limited pedagogy to implement the new curriculum and negative attitudes towards the new curriculum reform many cited in the literature as to why teachers resist to curriculum change (Tshireko, 2013).

The findings above are insightful that for STEM teaching and learning to be successful teachers need to grasp this reform as a shift in science and mathematics pedagogy. The thirty three percent (33%) of this study who do not think that a shift in teaching methods is required represent a significant number that cannot be ignored otherwise the whole exercise will ultimately fail if these teachers are not attended to.

4.1.4 Demands new approaches to assessment

As evidenced by results from the survey, sixty three percent (63%) of participants were aware that STEM teaching and learning demands new learning progress assessment approaches irrespective of their educational qualifications or the type of school they worked for. The results from interviews were consistent in saying that assessment methods for the new curriculum should involve assessment of practical work as well as a formal examination. For example Mr Zunde said:

I believe if we are to implement STEM education holistically, it should carry a substantial percentage, approximately forty percent (40 %) of the final mark and sixty percent (60 %) being constituted by the theoretical content

Education researchers, such as Kolk (2018), are of the opinion that projects must be included in assessment. He posits that STEM assessment methods that can be adopted include assessing the learning that occurs during the project-building process and considers the real-world skills
of collaboration, problem solving, decision making, and communication. Since project work requires students to apply knowledge and skills throughout the project-building process, the teacher will have many opportunities to assess work quality, understanding, and participation from the moment students begin working.

Thus, STEM teaching and learning necessitates that new assessment models be adopted otherwise the system will continue to produce the same type of graduates that are struggling to meet the requirements of industry. If new assessment models are not adopted, it would be very difficult to meet the goals of the STEM initiative.-Therefore, the remaining thirty seven percent (37%) who indicated that traditional assessment methods could be used to assess the learning progress are a threat to the successful implementation of the new curriculum

### 4.1.5 Demands new subject matter knowledge

The study shows that sixty percent (60%) of teachers are aware that the implementation of the new curriculum requires knowledge of all STEM related subject content. This is supported by information from literature that points to the fact that ‘the most important factor in ensuring excellence is great STEM teachers with both deep content knowledge in STEM subjects and mastery of the pedagogical skills required to teach these subjects well’ (PCAST, 2011). Teachers who possess a well-developed STEM pedagogical content knowledge, a constructivist paradigm of teaching and learning, and an ability to draw on a vision while reflecting on and during teaching to help negotiate challenges are well positioned to engage in the process of adaptive teaching (Stohlmann, Moore, Roehrig, & Gillian, 2012).

It is unsettling to note that forty percent (40%) of the teachers who took part in the survey think that the STEM curriculum can be implemented with their current pedagogical knowledge. Studies have shown that many countries have had to further train their teachers so that they can implement the STEM curriculum. Successful shifting of the pedagogical beliefs of teachers toward a reformed mindset is essential if professional development is to positively influence teaching in STEM classrooms (Crowther, Ferguson, & Hann, 2009). Professional development for teachers and proper training in STEM education is the driving force of STEM education (Aregamalage, Vijayanthi, & Hong Shen, 2017).

The implication of this finding is that a lot will need to be done, by way of teacher training and capacitation, to bring this large group of teachers on board so that they are equipped to implement STEM lessons.
4.1.6 Demands Teacher-Community collaboration

Sixty three percent (63%) of the teachers who participated in the study were aware that the STEM teaching and learning requires collaboration with their community. This finding agrees with the scholarship that says: ‘all sectors of the community must be engaged in visualizing, planning, and building ground breaking education efforts that mirror the area’s economic needs’ (Carraway, Rectanus, & Ezzell, 2012). Educators, experts, parents, and others must work together to integrate STEM activities into pupils’ daily lives: teams consisting of community-based STEM educators, afterschool youth development specialists, industries can co-develop and co-teach a collaborative curriculum focused on community needs (USA Government, 2015). Thus, the involvement of the community is important in ensuring the success of the STEM initiative. This is because the community has needs and expectations which can be articulated by engagement with educators.

Of concern is the thirty seven (37%) who are not aware of the need to engage the surrounding community. As mentioned in Section 1, the government of Zimbabwe hopes that STEM graduates will emerge to be critical thinkers and problem solvers who will create practical solutions to current and upcoming problems (Gandawa, 2016). It is therefore apparent that synergies must be created between schools and communities alike so that the education system produces the graduates that can take meaningful roles in their communities.

4.1.7 Demands a shift in teacher role

The study reveals that seventy percent (70%) of the teacher participants are aware that the success of STEM teaching and learning is greatly determined by their shift in teacher roles. The implementation of the STEM curriculum requires that teachers act as facilitators as well as learners when implementing the new curriculum. Results from the interviews support the idea that a shift in teacher roles is essential for the successful implementation of the new curriculum. For example Mr Mari said:

The new curriculum requires that the teacher be innovative, and must move away from the traditional teaching methods where he is the repository of knowledge to where we encourage pupil to go out and research, to think in unconventional ways and use all kinds of resources to acquire new knowledge

This is because the reformation of the instruction of subjects across STEM fields changes the role of STEM educators from being classroom/laboratory “dictators” to being facilitators of
students’ activities (Ejiwale, 2012). Assumption of these new roles (facilitation and guiding students towards solving real world problems) prepares them [students] to be independent thinkers. This is a shift from traditional teachers’ roles that tend to spoon feed students. Changes in both student and teacher roles in learning enables these classroom enterprises to stay abreast with the ever changing societies and their needs. Teachers must keep upgrading themselves through learning from the pupils themselves and from learning institutions. Interview results support the upgrading of teachers to enable them to implement the new curriculum as shown by the following statement;

I feel the teacher is being challenged to develop professionally if the content is to be smoothly implemented (Mr. Zama, April, 2018)

The 30% that are not aware of the need for teachers’ roles to change represent a significant threat to the successful implementation of the new curriculum. It means the teachers will continue to use the same old methods resulting in the churning out of graduates that are neither creative nor critical thinkers and are of little use to their communities.

4.1.8 Demands problem solving teaching approaches

Survey results indicate that 70 % of the teachers who took part in this research understand that the STEM curriculum involves pupils working on complex real world problems to come up with possible solutions. This understanding was shown in the interview results where there main approaches emerged. These are (1) Students do projects based on real life situations, (2) Discovery learning through experiments and (3) industrial visits and engaging the community

In relation to project based learning, Mr. Naku said

  teaching basic principles and its application and also project based learning where pupils are given real life problems to solve so that they can apply the knowledge that they would have acquired

Those who advocated for discovery learning made statements such as:

  STEM teaching and learning should involve discovery learning as well as active participation by students (Mr. Mari, April 2018)

On industrial visits and engaging the community, Mr. Zunde said:
Industrial visits are important as they give students an opportunity to see how theoretical knowledge is used to produce products.

Problem solving is one of the key facets of STEM teaching and learning. Scholars like Jolly (2014) agree that students must be given an opportunity to solve real life problems when she posits that, in a STEM lesson, the students’ work is hands-on and collaborative, and decisions about solutions are student-generated. She further says that students are given core concepts and once they grasp these, they are able to choose a problem and use their own creativity and curiosity to research, design, test and improve a viable solution.

The 30% who are of the idea that, problem solving is not part of STEM teaching and learning, are indirectly telling us that they are not ready or they are incapable of implementing the new curriculum. The ability to solve societal problems is one of the reasons why the STEM initiative was introduced by the Zimbabwe government. Teaching learners without inculcating in them the skills to be creative will produce the same graduates who are always looking for employment rather than be the agents of employment.

4.1.9 Curriculum document interpretation

The study reveals a staggering 56% of participants indicating that they had difficulties in interpreting STEM curriculum documents. The teachers with this lack of knowledge were fairly evenly spread across the five schools used in this study. This is not surprising as it concurs with a study done in Saudi Arabia by El-Deghaidy & Mansour (2015) where they concluded that ‘majority of the teachers who participated in the study believed that technology as hardware (e.g. computer, laptop, camera, iPad, etc.) is a core element for the integration of STEM in the classroom. This showed that teachers did not have sufficient understanding of the T in STEM. It also showed that science teachers may not have an adequate understanding of the nature of science and technology and the interactions between these two disciplines, when and if integrated.’

It is therefore of major concern that nearly half, forty four percent (44%) of participants indicated that they had problems in interpreting STEM curriculum documents. A failure to understand the documents means that appropriate implementation of the new curriculum is not possible.
4.1.10 Calls for teacher to teacher collaborations

The study reveals that seventy seven percent (77%) of the participants were aware that for the STEM initiative to succeed, teachers must engage each other and cooperate in implementing the new curriculum. According to Vangrieken et al (2015), teacher collaborations can involve discussing aspects of the didactics of teaching, problems teachers meet in their daily practice, observing each other in the classroom, discussing each others’ functioning, and critical examination of teaching. This is how it should be and as espoused by Novak (1998), to meet the needs of today’s learners, the tradition of artisan teaching in solo practice classrooms will have to give way to a school culture in which teachers continuously develop their content knowledge and pedagogical skills through collaborative practice that is embedded in the daily fabric of their work. He goes on to say that teacher collaboration supports student learning, and the good news is that teachers who work in strong learning communities are more satisfied with their careers and are more likely to remain in teaching long enough to become accomplished educators.

The 23% who are of the idea that teacher collaboration is not necessary may be saying so due to a variety of reasons. A perusal of literature shows that some of the reasons why teachers are unwilling to collaborate include personal characteristics of teachers such as not wanting to invest in effort, a lack of skills or training, unwillingness to collaborate, confrontations with conflicts that could be avoided, and mismatched personalities or pedagogical philosophies. (Bovbjerg, 2006)

When teachers share experiences and subject content notes in their areas of expertise, it becomes easier to implement the new curriculum and learners will ultimately benefit.

4.1.11 Driven by the Unhu/Ubuntu Philosophy

Unhu/Ubuntu is a Bantu term which when translated means ‘humanity towards each other’ (New World Encyclopaedia, 2016). It is a philosophy which thrives on the vision of a perfect and virtuous individual. It traces the emergence of Unhu/Ubuntu” as a common ground of consciousness that all Africans or Bantu tribes in Zimbabwe share (Sibanda, 2014). This study however, revealed that fifty three percent (53%) of participants were not aware that the philosophy of Unhu underpins STEM teaching and learning in Zimbabwe. This finding is worrisome as it is against researchers recognitions that Zimbabwe’s education system seeks to produce a well-rounded individual. The new STEM initiative recognises that for its goals to
succeed its implementation should be driven by the Unhu/Ubuntu philosophy. This is because the philosophy makes education meaningful to Zimbabweans and Africans at large. In line with this thinking, Tirivangana (2013) bemoans that meaningful education must respond to the needs of a people as directed by a people’s philosophy. In referring to Africans, he further says that being educated means being and living as a better African, and being a better African means in practical terms being an engineer, driver, pilot, teacher, whatever, who serves Africa and Africans because he or she has Africa and Africans at heart.

4.2 TEACHERS’ RESPONSES TO THE STEM CURRICULUM

The study revealed mixed responses by the participating teachers towards STEM teaching and learning. These fell into two main categories: (1) Teachers views of the success of STEM teaching and learning and (2) classroom practices. These are discussed in turn in the ensuing sections.

4.2.1 Teachers Views of the Success of the STEM teaching and learning

At all the schools that were used in this study, there were teachers who thought the initiative would succeed and others who thought it would not. Figure 4-5 below depicts that fifty six percent (56%) of the teachers who participated in this study are of the view that the STEM curriculum will not be successful in Zimbabwe.

![Figure 4-2: Opinions on success of STEM initiative](image)

This finding is in line with the finding of a study done in Malaysia which revealed that some teachers did not think STEM teaching and learning, implemented in that country in 2017 would succeed for a number of reasons (Talib & Ramli, 2017). Some of the reasons cited by these authors included that teachers (1) lacked STEM teaching and learning capacitation, (2) lacked
motivation (3) failed to interpret the STEM teaching and learning curriculum (4) were not provided with adequate teaching resources, and facilities. Interview results indicate that a lot needs to be done for the new curriculum to be successfully implemented. The following statement is quite revealing:

For STEM to be successful challenges like the shortage of qualified science teachers possibly due to brain drain and shortages of fully furnished science laboratories particularly in the rural areas need to be solved first. This finding is insightful as it points to the likelihood of the STEM teaching initiative failing.

4.2.2 Teachers’ Classroom practices

The results in Figure 4-3 below summarise the different classroom practices adopted by teachers.

![Figure 4-3: Variations in Teacher Classroom Practices](image)

The teacher classroom practice variations are discussed in more detail below:

4.2.2.1 Specialized subject matter teaching

Sixty percent (60%) of the participants indicated that they can only confidently teach content in the subject areas they specialised in their teacher training institutions. This proportion includes experienced as well as non-experienced teachers. This finding can be explained from
the literature position that says though many teachers may be interested in STEM teaching and learning they believe that they are not well equipped to implement this curriculum (Shernoff et al, 2017). This finding, that the majority of teachers still teach their specialised subject content, is a great threat to the successful implementation of the STEM initiative

4.2.2.2 Integration of STEM subject related concepts

The study revealed that ninety three percent (93%) of the teachers who participated in this study responded that they do integrate concepts from other subjects in their teaching. Science subjects are interrelated and it is impossible not to refer to concepts from other disciplines in delivering a lesson. By making connections among different branches of science and between science and other fields, an interdisciplinary approach helps students learn and experience first-hand the relevance of each subject as an integrated whole (Botts, 2018)

These findings are somewhat peculiar as they do not seem to follow the pattern of responses given by participants. From the foregoing, it has already been noted that sixty percent (60%) of the participants indicated that they can only confidently teach content in their specialised subject areas and fifty six percent (56%) had problems interpreting curriculum documents. Added to this is the fifty six percent (56%) of participants who do not think that the implementation of the new curriculum will be successful. Based on these findings, it is therefore unlikely that ninety three percent (93%) of the participants are integrating concepts from other subjects in their teaching.

4.2.2.3 Retention of subject based teaching and learning methods

A large percentage of eighty four (84%) of the teacher participants indicated that they are still using the traditional teaching and learning -the traditional-separatist methods. This means that teachers are only concentrating on delivering lessons that cover information pertaining to their subjects only. This teaching of STEM related subjects separately has been traditionally occurring in school and university settings for decades (Herschbach, 2011). Notably, this abstract way of learning ignores the real-life problem-solving contexts that exist and the knowledge gained is often not retrievable in real-life, problem-solving context (Berry, Chalmers, & Chandra, 2016). By integrating the STEM disciplines teachers are able to implement engaging hands-on learning opportunities that mirror real-world projects. The continued retention of subject based teaching and learning methods by teachers becomes a serious threat to the attainment of STEM curriculum initiative goals. This therefore means that the aim to resuscitate the Zimbabwean economy will remain a dream pipe.
4.2.2.4 Adoption of supportive STEM teaching and learning approaches

The study revealed that seventy nine percent (79%) of the teachers who participated in this study indicated that they have adopted learning approaches that are aligned to STEM teaching and learning. This agrees with assertions by scholars such as Hom (2014) who argue that the STEM curriculum involves an interdisciplinary and applied approach. In other words, rather than teach the four disciplines as separate and discrete subjects, STEM integrates them into a cohesive learning paradigm based on real-world applications.

Once again, this finding does not fit with the general trend of findings of this study. Earlier on, it was noted that sixty seven percent (67%) of the participants were not aware that the implementation of the new curriculum requires a new pedagogical approach. It would therefore be unlikely that seventy nine percent (79%) of them have adopted supportive STEM teaching and learning approaches. The effect of this is that, in the current circumstances, it would be highly unlikely for the implementation of the new curriculum to succeed.

4.2.2.5 Assessment approach

Figure 4-4 depicts that fifty eight percent (58 %) of teachers who took part in the study claim that they are using STEM assessment models (SAM) whilst 42 % have retained the traditional non-STEM assessment model (NSAM).

According to Kolk (2018), ‘authentic assessment documents the learning that occurs during the project-building process and considers the real-world skills of collaboration, problem solving, decision making, and communication. Since project work requires students to apply knowledge and skills throughout the project-building process, the teacher will have many opportunities to assess work quality, understanding, and participation from the moment students begin working’.
Of serious concern is the forty two percent (42%) who are still using the traditional assessment models. This means that, for nearly half of the participants, it is business as usual. The researcher feels that, for the STEM initiative to succeed, a paradigm shift on the part of teachers is required. They have to assess learners’ understanding of particular concepts and how they go about trying to solve real life problems.

4.3 REASONS BEHIND TEACHERS’ RESPONSES TO STEM CURRICULUM

The section above shows that seventy nine percent (79%) the mixed reactions of teachers toward the STEM curriculum. However their reactions are negatively inclined towards the STEM curriculum. The reasons for such teacher dispositions towards the STEM curriculum revealed in this study fell into two main categories of: (1) teacher capacitation and (2) access to teaching and learning resources.

4.3.1 Teacher Capacitation

Figure 4-6 depicts that sixty seven percent (67 %) of teachers who took part in the study claim that they did not receive any professional development in-service training to implement the STEM curriculum. To this, Tshili (2016) says the government of Zimbabwe has identified this problem and it has plans to ‘train 7 000 science teachers in the next two years to boost STEM. Without capacitation teachers remain limited on what STEM content to teach and how to teach it (Mpofu & Vhumuruku, 2017).

![Figure 4-5: Teacher capacitation responses](image)

In Europe, many countries have realised that ongoing professional development keeps teachers up-to-date on new research on how children learn, emerging technology tools for the
classroom, new curriculum resources, and more (Scientix, 2016). Such workshops also enable teachers to access sources of interdisciplinary action plans for STEM lessons. Education is an ongoing process for individual teachers and capacity building is important for the success of the STEM initiative. Teachers get to interact with other professionals where ideas are shared on what methods are more likely to work in the classroom.

### 4.3.2 Access to teaching and learning resources

Figure 4-7 depicts three categories of teacher variations in access of STEM teaching and learning resources.

![Bar chart showing access to teaching and learning resources](image)

Figure 4-6: Accessibility to STEM teaching and learning resources

#### 4.3.2.1 Provision of STEM education teaching and learning resources

As indicated in Figure 4-7 above, the majority (72%) of the teachers who participated in this study indicated that they were not provided with teaching and learning resources to implement the STEM curriculum. This provides a plausible reason as to why most of these teachers are retaining their subject content based teaching and methods. STEM lessons are active lessons where students define problems, conduct background research, develop multiple ideas for solutions, develop and create a prototype and then test, evaluate, and redesign them (Jolly, 2014). Integrated STEM education often requires numerous materials and resources for students to investigate solutions to real world problems through designing, expressing, testing, and revising their ideas. Stohlman et al (2012) say that required materials can include construction tools such as saws, measuring devices, and hammers; electronic materials such as computers, design programs, robotics kits, and calculators; and other materials used in design,
which could include wood, styrofoam, glue, cardboard, or construction paper. However, when resources are not provided for teachers the successful implementation of the STEM curriculum remains doubtful.

4.3.2.2 Access to STEM education literature

Since STEM education and learning is a relatively new phenomenon in Zimbabwe, most teachers maybe unaware of how to prepare and deliver a successful lesson. It is therefore critical that teachers have access to STEM teaching and learning literature so that they are kept abreast of what is happening elsewhere. In this study, 28% of the participants indicated that they had no access to STEM literature.

Literature is important as it helps teachers in designing innovative lessons and learn what others are doing to make their lessons a success.

4.3.2.3 Provision of STEM education implementation frameworks

The study revealed that fifty eight percent (58%) of the teacher participants indicated that they had not been provided with any implementation framework. According to UNESCO (2017) a framework, when used in any context, implies a means of organizing and managing content (policies, procedures, concepts and so on) in systematic ways In other words, a curriculum framework sets the parameters, directions and standards for curriculum policy and practice. This means that, even if teachers who participated in the study are teaching STEM concepts, there is no uniformity in the way the new curriculum is being taught. Implementation is defined as a specified set of activities designed to put into practice an activity or program of known dimensions whilst a framework is a particular set of rules, ideas, or beliefs which you use in order to deal with problems or to decide what to do (Collins, 2018).

The absence of a framework, to work with, means that there is no general consensus in the type of graduates that we expect to be produced using the new curriculum.

4.4 CHAPTER SUMMARY

This chapter has given a discussion of findings of the study. It has shown how the findings answer the three research questions. The results indicate that a significant number of science teachers are conscious of what it entails to teach the STEM teaching and learning curriculum whilst some of them are not fully aware of what is expected of them. The results also show that, in terms of responding to the STEM initiative, some of the science teachers are not up to
the task and are still engaging in the traditional teaching and assessment methods. As shown in this chapter, there are several reasons why teachers have not changed their pedagogies. For example, they do not have access to relevant literature as well as access to funds to procure materials to use in the classrooms. The next chapter looks and conclusions that were drawn from the study and some recommendations that were done.
CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 INTRODUCTION

This chapter summarizes and concludes the study as well as puts forward recommendations. It is organized in four summary components, each focusing on what was described and presented in each chapter. After the summary of chapters comes the conclusions that were arrived at when the study ended. The chapter then ends with recommendations that can be taken on board for the successful implementation of STEM teaching and learning in Zimbabwe.

5.1 STUDY SUMMARY

This study is reported in five chapters as summarised in the ensuing sections.

5.1.1 Chapter 1

Chapter 1 introduced this study by giving a brief background to the research topic. The research problem was outlined and the three research questions were stated. The research questions were then converted to three manageable research objectives. Also include in the chapter is the significance of the study as well as the assumptions that were made prior to embarking on the study itself. The delimitations and limitations were also noted. Furthermore, the key terms which are Curriculum Reform Awareness, Curriculum Reform Response and STEM teaching and learning were clearly defined.

5.1.2 Chapter 2

Chapter two was devoted to the review of literature related to this study. It also contains a possible conceptual framework for STEM teaching and learning. The review of literature was done in several stages. Firstly, the reforms to the science curricula around the world were presented followed by science curricula reforms in Africa. It was revealed from these reviews that a number of countries have reformed their science curricula towards STEM teaching at learning. The chapter also takes a closer look at the status of STEM education in Zimbabwe where it was noted that the reforms are still in their infancy with full implementation still to be achieved. The concept of Integrated STEM teaching and learning is also discussed and this was
followed by the presentation of a conceptual framework for the new curriculum. The conceptual framework is seen to consist of three main pillars; the teacher, CRA and CRR.

5.1.3 Chapter 3
The chapter starts by describing the research context which revealed that the schools selected for this study are all in Mashonaland East province of Zimbabwe. The curricula followed by these schools are also touched on. This was followed by describing the CSS as the research design that was used for the study. The manner in which research authority was sought and granted is presented and this is followed by a description of how the LSQ and SSI guide were used to generate data. The chapter ends with a discussion on the various stages followed in analyzing the data that was generated in the field.

5.1.4 Chapter 4
This chapter presented and discussed the research findings. The results were put into categories according to how they answered the research questions. The first category presented results on teachers’ understanding of STEM teaching and learning. This category had eleven components that focused on what it means to implement STEM education. Graphs and pie charts were used to show the results. These presentations were complimented by results from interviews. The second category contains results measuring participants’ responses to the introduction of the new curriculum. The responses were on teaching methods, assessment methods as well as their views on the successful implementation of the new curriculum. Lastly the chapter presented results on some of the reasons on why science teachers responded to the STEM initiative in the manner they did.

5.1.5 conclusions
The research objectives that guided this study are (1) to determine the level of consciousness of science teachers with regards to the STEM curriculum, (2) to describe how teachers are responding to STEM teaching and learning and (3) to explain why teachers are responding the way they are doing to STEM teaching and learning reform.

The study concludes that a significant number of science teachers are not aware of what it entails to implement the new curriculum. For instance, a sizeable number are not aware that the new curriculum requires new pedagogical approaches that are student centered. They still
use the traditional teacher centered approaches. A significant number is also not aware that the new curriculum demand new assessment methods. They continue to use the traditional methods of assessment. Some teachers are also not aware that the new curriculum requires teacher collaborations for it to be successfully implemented.

In terms of teacher response to the new curriculum, it can be concluded, based on this study, that a significant number of teachers have not changed their classroom practices as it is still business as usual and the majority of them do not think that the implementation of the new curriculum will be successful.

A significant number of participants indicated that they had no access to resources, such as a guiding framework to implement the new curriculum. Some of them have not been trained to implement the new curriculum. This therefore means that a lack of resources and teacher capacitation are responsible for the way teachers have responded to the STEM initiative.

5.2 RECOMMENDATIONS

It is apparent that there are science teachers in school who are ill equipped to implement the STEM curriculum. These teachers need further training so that they are capacitated to deal with the new curriculum. Teachers colleges can be capacitated so that they are able to produce graduates familiar with the teaching and learning of STEM subjects.

The government can restrategise the way they want the new curriculum to be implemented. For example, they should provide an adequate implementation framework for use by science teachers. They should also enhance their awareness programmes and sponsor events such as science fairs that promote innovation by students.

The new curriculum requires a lot of resources in the form of well-equipped science laboratories, relevant textbooks, materials to use in project work, access to the internet etc. These must be provided to schools so the implementation of the STEM curriculum is a success.

There is need to create strategic partnerships with industries so that their needs are in tandem with what pupils are being taught

5.3 FINAL REMARKS

A follow-up study should be done and this must include more teachers and seek to have private and public schools represented from across all provinces.
REFERENCES


APPENDICES

Appendix 1: BUSE Letter of introduction

DEPARTMENT OF SCIENCE AND MATHEMATICS EDUCATION

P Bag 1020,
Bindura,
Zimbabwe
Tel: 0263 0782706531
Email: vmphfu@buse.ac.zw

BINDURAU \: UNI\RY OF SCIENCE EDUCATION

14 February 2018

TO WHOM IT MAY CONCERN

RE: RESEARCH INTRODUCTION LETTER: CHIBOWORA ARTWELL
REGISTRATION NUMBER: B1543569

The above matter refers.

Mr. Chibowora Artwell is a Post Graduate Diploma in Science Education bona fide student of
Bindura University of Science Education in the Faculty of Science Education.

He wishes to undertake research entitled: “Science Teachers’ Awareness and Responses to
STEM Teaching and Learning in Zimbabwe”. This research is done in partial fulfillment of
the Post Graduate Diploma in Science Education programme - Biology of Bindura University.

On behalf of the Faculty of Science Education and Bindura University of Science Education,
the Department of Educational Foundations, therefore, is kindly requesting you to permit the
above mentioned student to carry out his research in your institution (s).

Your co-operation and assistance is greatly appreciated.

Kind regards,

C. Denhere (Prof)
Chairperson, Educational Foundations Department
Appendix 2  Application letter for research authority

House Number 2377
Morningside
Marondera
22 January 2018

The Secretary
Ministry of Primary and Secondary Education
P.O. Box CY121
Causeway
Harare

Dear Sir/Madam

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT SCHOOLS IN MARONDERA

This letter serves to ask for permission to carry out an educational research project at schools in Marondera, Mashonaland East Province. The title of the research project is: Science Teachers' Awareness and Responses to STEM Teaching and learning in Zimbabwe.

Purpose: The purpose of the study is to establish science teachers' awareness and how they are responding to STEM teaching and learning.

Procedure: I wish to conduct this study with science teachers at five schools (names supplied). Their participation is entirely voluntary. They will respond to a questionnaire by putting ticks against Likert scale questions. A few of them will be asked to take part in oral interviews by responding to semi-structured questions. Data that is subsequently generated will form the basis of conclusions and recommendations.

Risks, Discomforts or injury: There are no potential risks related to participating in this study. Although this may be the case, in the event of any direct injury resulting in participating in this study, I can be contacted on +263 772 330 499

Benefits, compensation and additional costs: The participants will not receive any financial or material benefits or any other compensation for taking part in this study. The research is being carried out in partial fulfilment of the requirements of the Post Graduate Diploma in Education at Bindura University of Science Education. Any financial costs related to
participation in the study will be met by the researcher. Although there are no financial rewards, participants may gain useful insights into issues associated with STEM teaching and learning that may improve the way they conduct their science lessons.

Confidentiality: All data and information generated by this study will be kept confidential. Names of participants and their schools will be assigned pseudonyms. The researcher will keep the data material in a secure place which will be destroyed by burning when the research has been completed.

Voluntary participation: Participation in this study is entirely voluntary, and anyone may choose not to take part. Participants who initially agree to take part may choose to withdraw at any time without any consequences. If the researcher decides to use any image of one or more participants, these will be blurred so that they cannot be visually recognised.

Additional Information: For any further information regarding their rights as research participants, anyone is free to contact Dr V. Mpofu at tvmpofu@gmail.com or on her mobile, +263 775 184 200.

Conclusion: I am happy to answer any questions on any aspect of this study that may be unclear to you. I can be contacted using the e-mail address or mobile number stated at the bottom of this letter.

Authorisation: You may authorise that the research be conducted by signing on this letter or by giving a separate written approval.

Yours sincerely

Artwell Chibowora

Reg. Number: B1543569

Mobile: +263 772 330 499

Email: achibowora@gmail.com
Appendix 3   MoPSE (Provincial & District) authority letter

All communications should be addressed to “The Provincial Education Director Mashonaland East Province” Telephone: 0279-24811/4 and 24792 Telex: Fax: 079-24791 E-mail: moesacedme@hotmail.com

Reference: D/ Chidzora
E.C. No.: P1543569

Ministry of Primary & Secondary Education
Mashonaland East Province
P.O. Box 752
Marondera
Zimbabwe

16 February 2018

Mr./Mrs./Miss

CHIDZORA ALTWEWEL

PETERHOUSE COLLEGE

MARONDERA

PERMISSION TO CARRY OUT RESEARCH IN SCHOOL FOR EDUCATIONAL PURPOSES: MR./MRS./MISS. ...................... E. C. NO. ......................
STUDENT I. D. ...................... TEACHER AT ...................... SCHOOL

Reference is made to your minute dated .............................. Please be advised that permission has been granted that you carry out research work in our schools. You are accordingly being asked to furnish the Ministry with information about your findings so that we share the knowledge for the benefit of the system as well as our nation at large.

We wish you all the best and hope to hear from you after completing your project work.

HUMAN RESOURCES OFFICER – DISCIPLINE FOR PROVINCIAL EDUCATION DIRECTOR
MASHONALAND EAST PROVINCE

16 FEB 2018

PO. BOX 752, MARONDERA
ZIMBABWE TEL: 0279-21306

EDUCATION INSPECTOR
MIN. OF PRY. & SEC. EDUCATION
MARONDERA DISTRICT
16 FEB 2018

PO. BOX 374, MARONDERA
ZIMBABWE TEL: 0279-23618
Appendix 4  School authority letter

House Number 2377
Morningside
Marondera
22 January 2018

The Head

P.Bag
Marondera

Dear Madam

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT YOUR SCHOOLS

This letter serves to ask for permission to carry out an educational research project at schools in Marondera, Mashonaland East Province. The title of the research project is: Science Teachers’ Awareness and Responses to STEM Teaching and learning in Zimbabwe.

Purpose: The purpose of the study is to establish science teachers’ awareness and how they are responding to STEM teaching and learning

Procedure: I wish to conduct this study with science teachers at five schools (names supplied). Their participation is entirely voluntary. They will respond to a questionnaire by putting ticks against Likert scale questions. A few of them will be asked to take part in oral interviews by responding to semi-structured questions. Data that is subsequently generated will form the basis of conclusions and recommendations.

Risks, Discomforts or injury: There are no potential risks related to participating in this study. Although this may be the case, in the event of any direct injury resulting in participating in this study, I can be contacted on +263 772 330 499

Benefits, compensation and additional costs: The participants will not receive any financial or material benefits or any other compensation for taking part in this study. The research is being carried out in partial fulfilment of the requirements of the Post Graduate Diploma in Education at Bindura University of Science Education. Any financial costs related to participation in the study will be met by the researcher. Although there are no financial
rewards, participants may gain useful insights into issues associated with STEM teaching and learning that may improve the way they conduct their science lessons.

Confidentiality: All data and information generated by this study will be kept confidential. Names of participants and their schools will be assigned pseudonyms. The researcher will keep the data material in a secure place which will be destroyed by burning when the research has been completed.

Voluntary participation: Participation in this study is entirely voluntary, and anyone may choose not to take part. Participants who initially agree to take part may choose to withdraw at any time without any consequences. If the researcher decides to use any image of one or more participants, these will be blurred so that they cannot be visually recognised.

Additional Information: For any further information regarding their rights as research participants, anyone is free to contact Dr V. Mpofu at tvmpofu@gmail.com or on her mobile, +263 775 184 200.

Conclusion: I am happy to answer any questions on any aspect of this study that may be unclear to you. I can be contacted using the e-mail address or mobile number stated at the bottom of this letter.

Authorisation: You may authorise that the research be conducted by signing on this letter or by giving a separate written approval.

Yours sincerely

Artwell Chibowora

Reg. Number: B1543569

Mobile: +263 772 330 499

Email: achibowora@gmail.com
Appendix 5: Participant consent form

I……………………………………………………………………………………..agree to participate in the research titled Science Teachers’ Awareness and Responses to STEM Teaching and Learning in Zimbabwe.

Please put a tick in the relevant box:

YES □

I further agree to be video recorded during the study

NO □

YES □

I give permission for anonymised data to be presented in research reports

NO □

YES □

I understand that my participation is voluntary and that I am free to withdraw at any time

YES □

NO □

_________________________________             _______________________________
Name of research participant                         Designation

_________________________________             _____________________________________________
Signature                                             Date

_________________________________                 ________________________________
Researcher’s name                                     Signature
Appendix 6: Likert Scale questionnaire

Section A: Background

Please put a tick in the relevant box

1. Please state your gender:
   Male ☐ Female ☐

2. Please indicate your age
   20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60-69 ☐ 70+ ☐

3. What is your highest academic qualification?
   NC ☐ ND ☐ Bachelor’s degree ☐ PGCE ☐ PGDE ☐ Other ☐ (please specify).................................................................

4. Type of school
   Government ☐ Private ☐

5. Please indicate current level being taught
   Forms 1-2 ☐ Forms 3-4 ☐ Forms 5-6 ☐

6. How many years have you been teaching?
   0-5 ☐ 6-10 ☐ 11-15 ☐ 15+ ☐

Section B: Science teachers’ consciousness about the STEM curriculum in Zimbabwe.

Instructions: Please complete the following scale by putting a tick in the appropriate box corresponding to your belief. Use the following key to determine your answer.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. STEM education is a curriculum based on the idea of educating students in four specific disciplines — science, technology, engineering and mathematics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. STEM education is a curriculum that emphasises on the teaching of STEM related subjects concepts such as mathematics, Physics, Chemistry, Biology etc.

3. STEM curriculum demands that I shift my pedagogical approaches

4. The STEM curriculum demands new ways of assessing students

5. The STEM curriculum demands my knowledge of all the STEM related subject content

6. The STEM curriculum requires me to engage the community in my teaching

7. The STEM curriculum requires me to assume a facilitator and learners’ role

8. The STEM education curriculum my students are challenged by complex problems related to real world scenarios

9. I am in possession of the new curriculum documents and I have read with understanding what this curriculum expects of me as a teacher.

10. I have attended STEM education workshops organised at national, provincial, district and school level.

11. The STEM curriculum demands that I engage other subject teachers in delivering subject lessons

12. STEM education in Zimbabwe is grounded in the philosophy of Unhu/Ubuntu.

---

Section C: Teachers responses to the STEM teaching and learning initiative

Please put a tick in the appropriate box

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I have been trained to implement the STEM education curriculum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I can only teach content in my area of specialisation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. I am integrating the concepts from other subjects in my subject lessons.

4. I have been provided with teaching and learning materials to implement the STEM education curriculum.

5. I am optimistic that the implementation of the STEM education curriculum will be successful.

6. I took part in the design and development of the new curriculum.

7. I have access to magazines and the internet to search on how to implement the STEM lessons in my subject area.

8. I was provided with a clear guiding framework on how to implement the STEM education curriculum.

9. I am using methods of teaching that are aligned to STEM teaching and learning.

10. I have adopted assessment models that support the STEM curriculum.

11. I am still employing subject based methods in my teaching.

12. I am using the same methods of assessment I have been using with the same replaced curriculum.

**Concluding remarks**

Thank you for your cooperation.
Appendix 7: SSI Guide

Section A - Participant background

<table>
<thead>
<tr>
<th>Session Details</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant</td>
<td></td>
</tr>
<tr>
<td>Session Number</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>Venue</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td></td>
</tr>
</tbody>
</table>

Section B - SSI Items

1. What subject do you teach?

2. What is your understanding of STEM teaching and learning?

3. In your opinion what teaching approaches are appropriate for STEM teaching and learning?

4. What content does the new curriculum require you to teach?

5. What assessment methods does the new curriculum demand?

6. How are you including concepts of STEM teaching and learning in your lessons?

7. What demands are placed on you as a teacher by the new curriculum?

8. How successful do you think the STEM curriculum will be?

Section C - Concluding remarks

Thank you for participating in this interview session. Are there any comments or question that you may want to bring to my attention?