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Research Article

National STEM Education Framework: Teachers' Perspectives on the 2015-2022 Curriculum Cycle

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Abstract
Throughout the world, nations are busy investing in Science, Technology, Engineering and Mathematics (STEM) to prepare innovative minds that can spearhead the development and sustainable growth of their economies. Zimbabwe's participation in the global economy is premised on the preference for STEM education system. The introduction of the Competence-Based Curriculum (CBC) in Zimbabwe meant a shift in the general aims and objectives of the education system. The transformation meant a move from an academic oriented and content-focused curriculum to one that is skills-based, giving prominence to continuous assessment over final examinations. To explore classroom practitioners' perceptions of the first cycle of the CBC, 20 purposively selected STEM teachers participated in the study. A qualitative research approach and case study design were adopted as study methodology. Thematically analysed data were collected through focus group interviews with participants. The study focused on support systems available for STEM education in secondary schools and how the absence of the national framework affects its implementation. The study found that there were limited support systems for STEM education as some schools did not have adequate facilities and equipment such as science laboratories, apparatus, science consumables, computer laboratories, computer hardware and software among others. It came out from the study that the absence of national framework had negative effect on the implementation of STEM education in secondary schools. The study concluded that though the secondary schools experienced constraints in implementing STEM education there were noticeable pockets of good practices in some schools, for example, learners graduating with competences for life skills. The study recommended that the schools should engage stakeholders for support in provision of required resources. The Ministry of Primary and Secondary Education should expedite the development of a national framework for the effective implementation of STEM education.

Keywords: Competence-Based Curriculum, Content-Focused Curriculum, STEM Education Framework

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1. INTRODUCTION

The introduction of the Competence-Based Curriculum (CBC) in Zimbabwe meant a shift on the general aims and objectives of the education system as stipulated in the Curriculum Framework for Primary and Secondary Education, 2015-2022. CBC is a curriculum that emphasises what learners are expected to do rather than concentrating on what they are expected to know. In other words, it implies that learners can acquire and apply the knowledge, skills, values and attitudes to solve situations they encounter in everyday life (MoPSE, 2020). The transformation meant a move from an academic oriented or content-focused curriculum to one that is skills-based. In line with this development, MoPSE (2015) and Chitate (2016) purport that the decision to develop the Curriculum Framework was made in the context of the government's focus on preparing Zimbabwean learners for the needs of the 21st century and the changes in global education standards. Zimbabwe's participation in the global economy is premised on an education

system with a Science, Technology, Engineering and Mathematics (STEM) bias (MoPSE, 2015). In the same vein the Ministry of Higher and Tertiary Education, Innovation, Science and Technology Development (MHTEISTD) is implementing Education 5.0 in form of; Teaching, Research, Community Service, Innovation and Industrialisation to move the nation towards attaining the status of a middle-income by 2030 (Government of Zimbabwe, 2018). STEM is influencing educational practice from basic to tertiary education. In agreement, Mpofu, (2019) postulate that, today, it is undeniable that STEM are strong drivers of competitive national economies. Thus, throughout the world, nations are busy investing in STEM with the hope of grooming innovative minds to spearhead the development and sustainable growth of their economies.

There is need for a national STEM education framework to complement the new developments in MoPSE and MHTEISTD. However, there seems to be policy dissonance, as a result Zimbabwe does not have a clear and accessible framework. Mpofu (2019) observes that the two ministries were failing to agree on the meanings of STEM education among other challenges. In marked contrast to the position of MoPSE, MHTEISTD sees STEM rather than STEAM as the solution for the economic challenges facing the country (Chitate, 2016). While recognising the centrality of STEM, in the new curriculum, MoPSE, insisted on adding arts and heritage studies, resulting, in the STEAM disciplines. Chesky and Wolfmeyer, (2015) highlight that, what is unique about STEM is that mathematics and science are no longer enough for knowledge acquisition of a modern citizen, but must be intertwined with technology and engineering. In the updated curriculum, teachers play a key role in designing and implementing continuous assessment tasks in all learning areas. This study acknowledges that teachers are essential to supporting STEM framework development and learning, hence, interactive-discussions to clarify understanding of the different issues. Accordingly, the authors realised a noticeable and critical need for stakeholders to agree on what STEM education is. Also, how policy dissonance is affecting implementation from a philosophical and sociological perspectives.

1.1. Literature Review

1.1.1. STEM Education

Chesky and Wolfmeyer, (2015) indicate that; 'STEM' began as 'SMET', standing for science, mathematics, engineering, and technology. In the 1990s the National Science Foundation (NSF) coined the term in order to emphasise the importance of these four distinct disciplines. According to APA (2022), the term STEM is used in a variety of contexts and brings with it many different meanings. In the education community and society at large an activity can be considered STEM if any two of the four disciplines mentioned above are intentionally emphasised (Milford & Tippett 2015; Chesky & Wolfmeyer, 2015). STEM education empowers learners with the most important skills that they need in order to be productive citizens. Such skills include: critical thinking and problem-solving; collaboration and leading with influence; agility and adaptability; taking initiative and being enterprising; effective oral and written communication skills; capability to access and analyse information. Provision of these skills would prepare learners to take part and contribute meaningfully to the exciting economies of the future (Milford & Tippett 2015; edvoiceviii, 2015; MoPSE, 2015). In this regard, STEM classrooms require teachers who hold knowledge and pedagogies associated with different STEM disciplines.

According to Chesky and Wolfmeyer (2015), the acronym is ambiguous, since educators have also used it to describe the inherent interconnectedness between the four disciplines, as well as create curricula and pedagogy that link them together. At the local level, Mpofu (2019) affirms that despite the increasing attention to STEM education worldwide, its stakeholders in particular educational institution managers and classroom practitioners are still grappling to come into terms with what constitutes STEM education and how it can move to classroom settings. In another dimension, Bell (2020) acknowledges that, education is always implicitly or explicitly a political issue. What is taught, what is not taught, how students are taught and how educational institutions are organised are fundamentally political questions. Education cannot be disconnected from wider views about the society in which it is located.

1.1.2. Education Policy and Governance

Solid, coherent policies and plans are the bedrock on which to build sustainable education systems, achieve educational development goals and contribute effectively to lifelong learning (UNESCO, 2021). Bell (2020) notices that, the policy process, is not neat and tidy but rather is a messy process in which, at any point in the policy cycle, participants negotiate over both implementation and outcomes. This could be the case world over and Zimbabwe is not an exception. Boronski and Hassan (2015) posit that, it is becoming increasingly apparent that education policy is influenced by global processes and trends. According to Bell (2020) the first element within policy development is the socio-political environment. For instance, each country in Africa has a unique historical context that is reflected in the specifics of its education system and the procedures that it uses in policy formation (David, 1994). Boronski and Hassan, (2015) agree when they say that policy is constantly being made and re-made, formed and re-formed, as those engaged in the policy processes bring their differential interpretations and influences to bear.

The wider socio-political environment provides the forum for ideological and philosophical debates and contested discourses from which the organisation of education is derived. In the United States, for example, STEM education policy is historically entrenched with nationalistic goals of militarism and economic security. These commitments have made broader turns towards global economic and power elite (Shizha & Kariwo, 2011). In Britain, the economy is the key priority for education policy making as noted by Boronski and Hassan, (2015). Education policy development in Zimbabwe has been very complex. There are many factors that have influenced the policy process. These include political, historical, sociological, economic and current forces of globalisation. For instance, the colonial period, in Zimbabwe witnessed the development of an education system that was discriminatory and was marked by exclusively limited access and lack of relevance. It was against this background, combined with the pressing socio-economic demands of the Zimbabweans, which triggered the need for radical change in education when the country won political freedom from Britain in 1980 (Chitate, 2016; Shizha & Kariwo, 2011).

As noted by Bell, (2020) policy is about both intention and outcome. The discourses that shape educational policy tend to be derived from perceptions about the overall purposes of the educative process. Boronski and Hassan, (2015) are of the opinion that;

> *It would be reasonable to assume that education policy makers and experts have learnt a great deal from the mistakes of the past and from the accumulated knowledge of decades of research but, as with most politically charged issues, education is rarely left to the experts and some educationalists are quite scathing of the way that governments have responded to the evidence gathered over the years. The lessons of past attempts at reform have not been learned. The lessons of past research and development have been treated as irrelevant not because they are genuinely inapplicable but merely because they are more than a few months old, or maybe because they challenge the preferred political agenda. Politicians of whatever persuasion are usually driven by their own political ideologies and the next new idea, as well as the next election. What we actually get tends to be a compromise based on government priorities and limited by budgetary targets rather than pedagogically sound principles*

The education systems of most African countries have evolved directly from the institutions and procedures that they inherited from the colonial power at independence (David, 1994). Phillips (2014) suggests the need for postcolonial theory to understand contemporary educational formations. In other words, post colonialism stresses the need to avoid the universalistic impulse at the core of many conceptions of this relationship. In this regard, Phillips (2014), further warns that educational policy and practice are concerned with knowledge and ethics, so close attention ought to be paid to the epistemologies of ignorance and the importance of epistemological responsibility. UNESCO, (2021) recommends the following themes for comprehensive policy review; overall assessment of the education system, teacher policies and capacity-building of teachers, and school principals, curriculum development, policies for evaluation and assessment of achievement, and mobile learning. With regard to STEM, Mpofu, (2019) suggests case studies and borrowing a leaf from Turkey, Egypt, and the United States of America STEM frameworks.

1.1.3. Evidence-Based Education

According to David (1994) to be successful, the process of education policy formation must provide for sufficient dialogue and realism to satisfy both the technical and the political requirements. Evidence-based policy informed this study with regard to educational framework development. Evidence-informed policy refers to policies that enable or encourage the use of programmes and practices proven to be effective in rigorous research, rather than the dissemination of generic principles of effective practice (Marta & Vivanet. 2021). This involves the production of operative and replicable structured programmes through experimental evaluation. Sources of evidence should include experimental studies, qualitative and mixed methodologies. Phillips (2014) asserts that many proponents of the idea of evidence-based education not only have argued that such evidence might play a role in educational policy and practice but also have taken the stronger position that educational policy and practice should be based on such evidence. According to Davies (1999) evidence-based education operates at two levels. The first is to utilise existing evidence from worldwide research and literature on education and associated subjects. The second level is to establish sound evidence where existing evidence is lacking or of a questionable, uncertain, or weak nature. David (1994) claims that effective development of education systems in Africa ultimately depends on the ability of African governments to develop a workable process for formulating coherent education policies and the capacity to translate policy into realistic investment and implementation plans.

Countries worldwide have already begun changing their policies to encourage the use of evidence in schools (Marta & Vivanet, 2021). However, there have been a number of recent criticisms about the gap between the teaching and the research communities, the relevance, applicability and quality of educational research, the non-cumulative nature of good educational research, and its effective dissemination (Davies, 1999). In agreement, Phillips (2014), makes an observation that, while, at first sight, it may sound obvious that educational policy and practice should be based on scientific evidence about "what works," a closer inspection indicates a far more limited role for evidence in education than what proponents of evidence-based education often seem to be after. Similarly, David (1994) notes that commissions reports, declarations and White Papers currently form the policy foundation for education reform and development in most African countries. However, these papers typically are wide-ranging, contain a long list of recommendations, often several hundred and are generally lacking any explicit discussion of priorities or the fiscal implications of the recommendations. Governments and donors struggle to use such documents as a basis for identifying program priorities and developing specific investment plans. Considering the observations by various scholars, the researchers have found it necessary, to examine the STEM teachers' experiences of the national framework and its support systems in Zimbabwe.

1.2. Theoretical Framework

1.2.1. Social Efficiency Theory

This study is guided by Social Efficiency Theory propounded by Bobbitt in 1913. The theory assumes that schools exist to help individuals adapt to the needs of society; as society becomes more complex, schools must transform themselves accordingly; and in this way they will help citizens develop the socially needed qualities of intelligence and efficiency (Mizikaci, Sarioğlu, Issoufou, & Enginyurt, 2021). In this theory efficiency implies a careful organisation and carrying out of educational experiences the learner must learn. This would be possible through creation and use of behavioural objectives by educators. The behavioural objectives should use desired learner behaviours outcomes which the educator may observe and assess (Schiro, 2013). The theory undertakes that educators should use scientific methods to determine the set of objectives students need to learn in order to grow and function as contributing members of society. Thus, Social Efficiency Theory educators believe curriculum objectives should be stated in behavioural terms: as observable skills, as capabilities for action, as activities people can perform, as demonstrable things people can do (Mizikaci, Sarioğlu, Issoufou, & Enginyurt, 2021, Kliebard, 2004). Hence, Social Efficiency curricular specify behaviour that is learned, not content that is acquired. (Social Efficiency Ideology: Scientific Technique of Curriculum Making), Therefore, according to Social Efficiency Theory, educators should act as agents of society, should determine the needs of society and the products (learners with skills) that fulfil those needs (Schiro, 2013). Consequently, through the lens of the Social Efficiency Theory, this study intended to examine the STEM teachers' perspectives regarding the problem under study.

2. METHODOLOGY

To explore classroom practitioners' perceptions on the first CBC cycle 2015-2022, 20 purposively selected STEM teachers participated in the study. That is, subject specialisation (e.g., Mathematics, Biology, Computer Science), at least two years of teaching experience in rural or urban schools, involvement in MoPSE curriculum and continuous assessment learning activities (CALA) development, and lastly participation in professional development programs related to STEM. Qualitative research approach and case study design were adopted as study methodology. The methodology is principally well-suited for understanding the experiences, perceptions, and practices of STEM education teachers in Zimbabwe. The qualitative approach allowed the researchers to consider various factors that might affect STEM education, such as cultural or political influences and schools' infrastructure. The case study design allowed the researchers to examine the broader context, including school policies, community involvement, and government support for STEM education. Focus group discussions (FGDs) were used to gather insights through interactive discussions among STEM education teachers. FGDs were effective in exploring collective perceptions, experiences, and attitudes. Thematically analysed data were collected. This involved organising and interpreting data to make sense of its meanings and implications. By organising these insights into themes, thematic analysis helped uncover key insights about teachers' experiences, challenges, and practices. It also helped researchers better understand the teachers' perspectives on the 2015-2022 curriculum cycle. Given the need for a comprehensive, unbiased and well-informed FGDs, the discussions began by a brief background to the development of the STEM framework in the Zimbabwean context. A combination of qualitative research, case study design, and FGDs was effective as each of these methods provided unique advantages that aligned well with the objectives of STEM teacher experiences, and contextual influences. Some challenges arose at different stages of the research process, some participants were reluctant to share their views openly in a group setting, especially politically related issues. To address these and other challenges, the researchers were ethically sensitive and ensured that participants' identities are protected in all reports. To ensure confidentiality, the STEM teachers were coded as T1-T20 to conceal the identification of participants. The integrated approach provided comprehensive insights that can inform policy, practice, and further research in STEM education.

The study was guided by the following research question: How do STEM teachers perceive the 2015-2022 curriculum cycle as embedded in the national STEM education framework in Zimbabwe?

The responses to the research question were presented under the succeeding themes:

- National STEM Education Framework,
- Implementation of STEM education,
- Support system for STEM education.

3. RESULTS AND DISCUSSION

3.1. National STEM Education Framework

The participants were asked to give their views on whether there was a national framework that was in place to guide STEM subjects in the 2015-2022 CBC. The participants' responses indicated a broad consensus that education policy development in Zimbabwe has been very challenging. It came out that there was no clear STEM framework which guided schools on effective implementation. Most of the responses showed that STEM education framework as a concept was still on paper until full attention was given. However, some participants were optimistic that in due course, the STEM education framework will take off. Some of the participants' responses revealed that:

- STEM Education is at its infancy and at the moment the country is translating that idea into reality (T3).
- You do not expect to achieve a legacy in a day (T6).
- It has been given a lip service without properly equipping the implementers with necessary skills to execute it, more so there is need for proper foundation at MoPSE level and ensure continuity at Tertiary level (T1).
- There are no proper strategies and real activities, activities are just on paper. So STEM cannot be implemented through rote learning T10).
- Considering that the STEM educational framework has been labelled as just an ideological apparatus, science is theorised even in instances where practical work is required (T5).

- Apart from all the positive STEM initiatives, it can never be denied that, politics play a vital role in making sure that we move at a tortoise' pace (T8).

The findings of the study revealed that there is need for a national STEM education framework to guide teachers and complement the new developments in MoPSE and MHTEISTD. The results of the study are consistent with Chauraya's (2023) observation that, efforts to mainstream STEM Education in the schools' curricular have been largely superficial and often limited to political pronouncements and unsustainable, non-inclusive strategies. Mpofu (2019) concludes that, Zimbabwe does not have a vibrant and accessible national STEM education framework because MoPSE and MHTESID fail to agree on the meanings of STEM education. In marked contrast to the position of MoPSE, MHTEISTD sees STEM rather than STEAM as the solution for the country's economic challenges (Chitate, 2016).

3.2. Implementation of STEM Education in Competence Based Curriculum

The CBC in Zimbabwe means that learners should acquire competencies to solve situations they encounter in everyday life and a transformation move from an academic-oriented curriculum to a skills-based one. Many factors have influenced the implementation process. There was growing concern over what was seen as strenuous CALA, too much theory, demotivated teachers, lack of essential STEM resources in the schools, limited industry involvement in STEM education, and gender related issues. A number of participants argued that the problem was lack of essential STEM resources for practical learning and teaching in the schools. Others suggested industry involvement in STEM education. Participants gave the following opinions:

- A few learners know the basics of how to manipulate laboratory apparatus (T15).
- We lack practicality and there is too much paperwork (T7).
- Our STEM education promotes the cognitive domain more than psychomotor domain due to lack of practical work (T20).
- Some experiments are far too dangerous to carry out in an ordinary classroom with improvised apparatus (T3).
- The economic system of Zimbabwe contributes to this challenge to a larger extent, teachers are demotivated to effectively implement STEM curriculum (T19).
- The biggest challenge was numerous CALAs. 45 CAlAs for a learner taking 9 subjects at Ordinary Level. This has forced some learners to reduce the number of STEM subjects to one (T11).
- The discord between MoPSE and MHTEISTD on STEM contributes negatively to the successful implementation of STEM Education (T5).
- STEM is taken as an elective hence only those who can afford can implement the policy (T1).
- The gap between Industry and Commerce on STEM is the reason why engineers are teachers in Zimbabwean schools (T14).
- With reference to Zimbabwe, most of the STEM beneficiaries from its inception are males (16).
- CALA is more theoretical than practical. The CALA marks are not reflective of learner performance due to a bonus based on teacher performance (T4).
- CALA workshops were rushed and educators were forced to implement something they did not understand. CALA has become an in class activity with no meaning to one's life and the nation (T9).
- CALAs are strenuous. They should be scraped off. CALA is an over load to the teacher (T13).

The introduction of the CBC in Zimbabwe meant that learners should acquire competencies to solve situations they encounter in everyday life and a transformation move from an academic oriented curriculum to skills-based. The results of the study indicated that there are many factors that have negatively influenced the implementation process. Thus, the results of this study are in contrast with Social Efficiency Theory, which suggests that educators should act as agents of society, and should determine the needs of society, and the products (learners with skills) that fulfil those needs (Schiro, 2013).

3.3. The Support System for STEM Education

The discussion on the support system naturally led to the scrutiny of the state of science laboratories, basic equipment and apparatus in schools. Concerns were raised about lack of funding for the STEM

curriculum especially in rural schools. Teachers were encouraged to improvise, but there was no framework to support the processes, time was wasted on simple experiments due to shortage of apparatus. The STEM teacher participants had this to say:

- Lack of funding for the STEM curriculum especially in rural schools and public schools. The Government is not allocating enough funds to STEM education (T2)
- STEM lacks a theoretical framework to support the implementation of science subjects (T12).
- They say we must improvise on basic equipment and apparatus, hence, most schools have narrow STEM curriculum that they offer (T17).
- STEM lacks a theoretical framework to support the implementation of science subjects coupled with acute shortage of laboratory equipment in many schools particularly in rural areas (T18).
- Yes, we spend the whole day on simple experiments due to shortage of apparatus (T4).
- Most schools do not have science laboratories and other relevant resources for implementation (T16).
- Most rural schools do not have the much needed infrastructure to implement STEM education. Learners in rural schools also lack the cultural capital to appreciate the importance of STEM education unlike their counterparts in towns (T20)
- Though we have to interact with science everywhere, we still need a laboratory such that we are able to verify things under our jurisdiction (T10).
- We are being failed by the environment, for example, for chemistry learners to understand concepts, they need to have updated apparatus (T6).

Figure 1. A school in one of the remote areas in Zimbabwe (Picture supplied by T.6.)

This study results acknowledge that teachers are essential to supporting STEM framework development and learning. In the CBC, teachers play a key role in designing and implementing continuous assessment tasks in STEM learning areas. Hence, a discussion to explore the support systems available for STEM education in secondary schools. It came out from the study that the backup for STEM education was limited especially in rural and public schools. The results of the study established that rural schools did not have the much needed infrastructure and requisite equipment to implement STEM education. The findings of this study are in disagreement with the assumption of the Social Efficiency Theory that schools exist to help individuals adapt to the needs of society; as society becomes more complex, schools must transform themselves accordingly; and in this way they will help citizens develop the socially needed qualities of intelligence and efficiency (Mizikaci, Sarioğlu, Issoufou, & Enginyurt, 2021).

4. CONCLUSIONS

The study examined the STEM teachers' perspectives on 2015-2022 curriculum cycle as embedded in the national education curriculum in Zimbabwe. The numerous shortcomings encountered by the teachers pointed to the lack of a consolidated STEM education standard or an ingenious structure for operational purposes. The absence of the national framework had negative effects on the implementation of STEM education in secondary schools. There was a broad consensus on the limited support system for STEM education as some schools did not have adequate facilities and equipment such as science

laboratories, apparatus, science consumables, computer laboratories, computer hardware and software among others. Though the secondary schools experienced constraints in implementing STEM education, there were noticeable pockets of good practices in some schools.

5. RECOMMENDATIONS

- There is need for MoPSE to design a vibrant and evidence-informed national STEM education framework which will be in line with global STEM education practices.
- STEM education teachers should have a direct contribution and involvement in educational policy/ framework formulation matters to narrow the gap between teaching and technical, relevance, applicability and political requirements among other factors.
- Considering the centrality of STEM in the Competence-Based Curriculum, the national STEM education framework should adapt to the needs of society as suggested by the Social Efficiency Theory.
- Given the socio-economic demands in Zimbabwe, MoPSE should organise in-service training programmes to equip STEM teachers with transformative pedagogies so that requisite skills and competences are imparted to learners.
- In view of the limited support rendered by the government for sustainable education systems, schools should engage various stakeholders for support in provision of required STEM education resources.

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