**Journal of Research in Instructional**
**e-ISSN: 2776-222X**
**Vol. 3(1) 2023, pp. 69 – 86**

# Curriculum innovation implementation for industrialization: A case of education 5.0 pre-service science and mathematics teacher preparation

Alois Matorevhu

Mutare Teachers' College, Zimbabwe

**Abstract:** Higher and tertiary education graduates in any country should possess job – relevant knowledge and skills to meet needs of industry. Consistent with this, the Ministry of Higher and Tertiary Education, Science, and Technology Development of Zimbabwe, adopted Education 5.0, comprising five components: teaching, research, community service, innovation, and industrialization. This case study sought to explore the understanding by science and mathematics teacher educators of Education 5.0 curriculum innovation implementation at 3 teachers' colleges in Zimbabwe. Science and mathematics teacher educators, purposively sampled participated in focus group discussions. To gain insight on Education 5.0 curriculum innovation implementation, policy documents were analyzed. Emergent themes were interpreted, guided by the interpretivist paradigm, which acknowledges multiple realities. Findings show that science and mathematics teacher educators were positive that Education 5.0 curriculum innovation implementation would cause socio – economic development. However, diverse interpretations of the Education 5.0 curriculum innovation seemed to threaten successful implementation. Therefore, curriculum innovation developers should ensure that implementers understand the envisaged innovation implementation to counter the adverse effects of diverse ontologies. Also, conditions should be conducive to successful curriculum innovation implementation.

**Keywords:** Curriculum innovation, diverse ontologies, education 5.0, innovation

# Implementasi Inovasi Kurikulum untuk Industrialisasi: Sebuah kasus pendidikan 5.0 persiapan calon guru sains dan matematika

**Abstrak:** Lulusan pendidikan tinggi dan tersier untuk negara mana pun harus memiliki pekerjaan – pengetahuan dan keterampilan yang relevan untuk memenuhi kebutuhan industri. Sejalan dengan hal tersebut Kementerian Pendidikan Tinggi dan Tersier, Pengembangan Ilmu Pengetahuan dan Teknologi Zimbabwe, mengadopsi pendidikan 5.0, yang terdiri dari lima komponen yaitu pengajaran, penelitian, pengabdian masyarakat, inovasi dan industrialisasi. Studi kasus ini berupaya menggali pemahaman para pendidik guru sains dan matematika tentang implementasi inovasi kurikulum pendidikan 5.0 di 3 perguruan tinggi keguruan di Zimbabwe. Pendidik guru sains dan matematika yang diambil sampelnya secara purposive berpartisipasi dalam diskusi kelompok terarah. Untuk mengetahui implementasi inovasi kurikulum Education 5.0, dokumen kebijakan dianalisis. Tema-tema yang muncul diinterpretasikan, dipandu oleh paradigma interpretivis yang mengakui banyak realitas. Temuan menunjukkan bahwa pendidik guru sains dan matematika berpositif bahwa implementasi inovasi kurikulum pendidikan 5.0 akan menyebabkan pembangunan sosial ekonomi. Namun, beragam interpretasi inovasi kurikulum pendidikan 5.0 tampaknya mengancam keberhasilan implementasi. Oleh karena itu, pengembang inovasi kurikulum harus memastikan bahwa pelaksana memahami implementasi inovasi yang diharapkan untuk melawan efek buruk dari beragam ontologi. Juga, kondisi harus kondusif untuk keberhasilan implementasi inovasi kurikulum.

**Kata Kunci:** Inovasi kurikulum, beragam ontologi, pendidikan 5.0, inovasi

**Received:** 21-05-2023
**Accepted**: 17-06-2023

**To cite this article**: Matorevhu, A. (2023). Curriculum innovation implementation for industrialization: A case of education 5.0 pre-service science and mathematics teacher preparation. *Journal of Research in Instructional*, *3*(1), 69–86. https://doi.org/10.30862/jri.v3i1.214

*Corresponding author: amatorevhu@gmail.com

## INTRODUCTION

Industrial growth in any country is important to boosting economic growth and citizenry welfare. Therefore to meet needs of industry, a competent human capital should be built, by ensuring that tertiary education graduates have job – relevant knowledge, skills and attitudes as exit competences (Bawakyillenuo et al., 2013; Nusantari et al., 2020). A knowledge economy premised on higher and tertiary education as a major driver of economic competitiveness is important for sustainable development, in both industrialised and developing countries (World Bank, 2003, 2019). Building knowledge bases through research and formation of human capital are some of the means identified (OECD, 2008), which tertiary education contributes to socio – economic development. Consistent with this, many countries over the world are investing in research and human capital development through science curriculum innovation in higher and tertiary education.

Global views reflect the important role of higher and tertiary education in industrialisation and socio – economic development (Chitate, 2016). Studies attribute rapid development of countries like China, India, Singapore and Brazil to effective tertiary education – industry links (Tan, 2018; World Bank, 2019; Wu, 2007). Innovation capabilities of such economies have been augmented by strengthening partnership between industry, tertiary institutions and government. Elsewhere, international research like Trends in International Mathematics and Science Study (TIMSS), and Progress in International Reading Literacy Study (PIRLS) show that with the view to form a strong socio – economic development base, Singapore created a highly effective school system evidenced by high levels of student achievement in science, mathematics and literacy (Deng, 2010; Tan, 2018). The education system focuses on preparing students for life and work in the 21$^{st}$ century by developing generic skills like critical thinking, collaboration, creativity and communication (4Cs). Also included are technological and multicultural literacy, civic and management skills. Generic skills also referred to as graduate attributes or 21$^{st}$ century skills are lifelong skills not specific to any class or subject which students need to learn to apply to life (Deng, 2010). They are transferable all- purpose skills essential in performing various tasks in a wide range of occupations. These global trends of change have initiated countries to reform the curriculum to equip learners with knowledge, skills and competences needed in the 21$^{st}$ century and beyond. In this regard, more than 40 countries which include Finland, Japan, Estonia, Norway, and Wales (United Kingdom), are participating in OECD Education 2030 project which aims to explore skills and competences needed for children to thrive in the 21$^{st}$ century (Gouëdard et al., 2020; Obielodan et al., 2021).

Science education is viewed worldwide as important in producing secondary school graduates who form the foundation for developing STEM compliant human capital for socio – economic development (Chitate, 2016; Docherty-Skippen et al., 2020). Many post – independence African governments are implementing innovated science education curricula since the beginning of independence era in the 1960s, with the view to improve economies of their countries. However, rapid fundamental changes made in many African education systems aiming to address imbalances created by colonial education systems, have created gaps between demand and supply of relevant high – calibre science teachers, since few teachers irrelevant to socio – economic needs are being produced. As a result teacher education institutions in Africa have not been able to produce enough relevant science teachers for respective education systems to meet national socio – economic needs. It is worrying that most of the challenges prevalent before the independence era are still around today (Ogunniyi & Rollnick, 2015)

Curricula reform is still on going in countries worldwide, and if teachers are not well prepared during either pre – service training or in – service training, curriculum innovation implementation may not be successful (Im et al., 2016). For instance South Africa introduced a post – apartheid curriculum which was later deemed too complex for teachers to implement and was replaced by a more conservative content – centred curriculum (Nakedi et al., 2012). Research literature shows that no science teachers can be better than the education system that produces them (Im et al., 2016). This implies that teacher education curriculum innovation should prepare well pre – service science teachers to enable them to produce secondary school science graduates who are ready to be productive in the national economy.

Innovation is a complex and multifaceted concept (Kogabayev & Maziliauskas, 2017), so there is no agreed definition. It can be conceived, defined, interpreted and understood in different ways, hence there are many definitions which are used across different fields in academia, industry, government, and service provision (Taylor, 2017). Many forms which innovation assumes include processes, products, services or anything that assists companies and countries to improve socio – economic development (Nicolaides, 2014). Introducing something new and useful like new methods, techniques, practices, or products and services is called innovation (Akhtar, 2018). It can also be referred to as use of knowledge and technology to develop or improve the production or performance, of products, services and processes that have value in terms of commercial impact or social benefit (United Nations Conference on Trade and Development, 2019). Value creation from knowledge leading to provision of new good or service to the market or finding new ways of producing products is OECD and International Development Research Centre (2010) view of innovation. Therefore from these diverse definitions, an innovation can be done by anybody who is capable of exploring existing phenomenon. An innovation can be radical consisting of completely new processes or products. When minor improvements are made to existing processes and products this is termed incremental innovation. Research and innovation create new knowledge which gives a nation leading edge in areas of science and technology. Through research innovative ideas evolve, and creativity develops which allows new value to be produced through implementation of new ideas. Impact of innovation is evidenced by huge leap in value creation and effective outputs resulting in national economic growth and development.

Regardless of various definitions, innovation has two categories which are technological innovation and managerial or administrative innovation. Technological innovation associates with adopting or adapting an idea that directly influences output processes, while administrative innovation involve changes in relation to resources allocation, policies and other organisational structure. Administrative innovation has the responsibility of facilitating implementation of new ideas as well as motivating staff to fully participate in implementation (Chandio, 2021; Mohd Zawawi et al., 2016). In business the common link of all innovations is application of new knowledge by profit – seeking entrepreneurs to create new sources of competitive advantage and business profit (Habiyaremye et al., 2022). It is crucial that in any country the government defines the mission and provide the necessary impetus for innovation to drive industrial development (Mazzucato, 2018). Innovation and R&D can foster socio – economic development if vast resources are allocated as illustrated by cases of US and China. However, due to the multifaceted nature of innovation, it is important that an operational contextual understanding is developed by all innovation implementation stakeholders.

Curriculum innovation is a complex process because on one hand it is a national affair expected to define knowledge, selecting skills that are viewed as most valuable (Labinjoh, 1975), for a nation to prepare for the future. On the other hand, curriculum innovation should respond to global concerns like globalisation, SDGs, environmental issues, international student assessments eg the PISA, TIMSS, and PIRLS (Gouëdard et al., 2020). In addition to these complexities, countries encounter challenges due lack of fidelity to curriculum implementation, implying existence of an implementation gap (Superfine et al., 2015).

Innovation is at the centre of industrial mutation which spurs national development through its ability to disrupt markets by rendering old technologies obsolete, continuously creating news ones that define long term growth trajectories (Habiyaremye et al., 2022). Availability of skilled innovative manpower is one of the fundamental pre – requisites for industrialisation of a country, hence higher and tertiary education should produce enough and relevant human resources for all socio – economic sectors of a country (Chitate, 2016). Application of science and technological innovation contribute to good quality of life and industrial progress of all nations (Akpan, 2010; Lelasari et al., 2021). Attempts by many countries to achieve sustainable development goals (SDGs) has caused science, technology and innovation (STI) to gain traction recently, such that it is prioritised in policy, legislative and strategic issues internationally (Habiyaremye et al., 2022). Therefore higher and tertiary education should be reconfigured to align it with the production of innovative human capital which industry needs to promote development in all socio – economic sectors. In line with achievement of SDGs higher and tertiary education should prepare enough and relevant science teachers for each country to equip secondary school graduates with the prerequisite industry linked STI competences.

On the backdrop of the need to promote industrialisation, the Ministry of Higher and Tertiary Education, Science and Technology Development (MHTESTD) of Zimbabwe adopted innovated curriculum Education 5.0. Internationally, science curriculum innovation has been influenced by various factors which include world events like the Sputnik Crisis and international trends like science and technology for socio – economic development, currently sustainable development goals (SDGs) 2016 – 2030, and millennium development goals (MDGs) 2000 – 2015. In Zimbabwe, many activities, among them Zimbabwe National Skills Audit, Design Analysis and Philosophical Analysis, were carried around 2018 with the view to transform university, teachers' college and polytechnic education (MHTESTD, 2019). The hypothesis that governed the critical skills audit was that low industrialisation levels could be a result of low skill levels and that developing and increasing skills would be the foundation for leapfrogging the economy. Indeed, Zimbabwe's average skill level of 38% differs from its literacy rate of over 94%. Under normal conditions, skill level and literacy level should be equivalent. Zimbabwe has one of the highest literacy rates in Africa and the globe, but its industrialisation is remarkably low. This implies that knowledge, skills, and awareness, which are crucial determinants of the degree of industrialisation, are inadequate (Murwira, 2019).

A Design Analysis of the education system premised on that higher education must produce goods and services, showed that University curricula in Zimbabwe comprised 3 missions namely: (1) Teaching, (2) Research, and (3) Community Service. This was coded Education 3.0 based on its 3 missions. The nature of Education 3.0 resulted in production of workers rather than producers of goods and services. In an effort to improve, university education was redesigned to Education 5.0 comprising five missions which are (1) Teaching, (2) Community Service, (3) Research, (4) Industrialisation, and (5) Innovation. Innovation and Industrialisation are two missions that were added to Education 3.0 to give Education 5.0 (Murwira, 2019). However, it is important to note that although the first three missions of Education 3.0 are present in Education 5.0, these missions should be carried out differently consistent with heritage based philosophy of Higher and Tertiary Education (Wuta, 2022). The heritage based philosophy states that advanced scientific knowledge from anywhere in the world should be contextualised to the environment for producing a competitive industry. In this vain ecosystems for innovation in order to industrialise and modernise are being created. The Education 5.0 policy papers state that the new technologies should come from the innovation centres being constructed at the HTE institutions. Additionally, industrial parks connected to these educational facilities will be established. The goal is to establish a network of innovative businesses, government agencies, and educational institutions that can work together to produce ground-breaking consumer goods ( MHTESTD, 2019; Murwira, 2019).

Higher and tertiary education plays a key role in innovation and economic growth through universities and colleges which develop new knowledge and technologies and apply them in economic growth (Chingozha et al., 2022). In the 2019 – 2023 MHTESTD strategic plan, stated goals focus on industrialisation as the ultimate target (MHTESTD, 2019). Based on this, MHTESTD has established new goals to develop the ministry into a creative and industrial center, with the ultimate aim of elevating Zimbabwe's economy to the upper middle class by the year 2030. So, the idea is to turn out creative graduates with an eye toward industry (Dziwa & Postma, 2020). The 2018 Zimbabwe National Critical Skills Audit (MHTESTD, 2018a) places a focus on bolstering science and technology to fulfill the innovation and industrial objectives of Education 5.0. Minimum Bodies of Knowledge (MBKs) were developed as part of the Zimbabwe National Qualification Framework with the goal of creating horizontal comparability across education and training credentials in the country (MHTESTD, 2018b). Therefore teachers' colleges among other higher and tertiary education institutions should restructure to develop human capital needed to achieve Education 5.0 goals.

Innovation in teacher education in the 21st century include integration of ICTs (computer, software, networks, satellite links, websites and other related systems into teaching and learning of teacher education programmes (Barakabitze et al., 2019). Also teacher education innovation includes new or modified teaching and learning approaches or instruction, to improve the quality of preparation of teachers. In this regard science teacher educators should understand policies and initiatives related to innovation in order for innovation implementation to succeed. Science teacher educators as the pivot in the preparation of science teachers need motivation so that they focus on being innovative and creative in preparing the envisaged science teachers (Akhtar, 2018).

Though the term innovation is used widely by policymakers, marketing specialists, business sector, and curriculum developers, it is sometimes applied as a metaphor, political promise, slogan or a buzzword rather than a scientific concept (Kotsemir et al., 2013). Premised on this it is necessary in teacher education curriculum innovation implementation to understand the nexus or connection between innovation and industrialisation, so that the goal of industrialisation is pursued aligned to the mandate of the institution. Therefore this study sought to explore understanding by science and mathematics educators of Education 5.0 curriculum innovation and its implementation at 3 teachers' colleges in Zimbabwe.

## METHOD

This study adopted a case study design in which the case was the Diploma in Education programme for producing science and mathematics pre – service teachers respectively. To generate data, six teacher educators (3 science and 3 mathematics), purposively sampled from 3 teachers' colleges respectively, participated in focus group discussions (FGDs). The participants were informed of the purpose of the study, and the granted consent to participate. These teacher educators were considered knowledgeable about science and mathematics pre – service teacher preparation in relation to Education 5.0, hence they were sampled. Validation of the focus group discussion (FGD) guide was done by 2 science educators and 2 mathematics educators (researchers) who would not participate in the study. Feedback from these researchers was used to improve wording of items in the FGD guide, hence its validation. The National Development Strategy 1 (NDS1) (Government of Zimbabwe, 2020), Doctrine Education 5.0, Zimbabwe National Critical Skills Audit (ZNCSA) (MHTESTD, 2018), and Zimbabwe National Qualification Framework (ZNQF) (MHTESTD, 2018), which constitute the implementation framework for Education 5.0 are documents that were analysed to gain insight on policy issues related to Education 5.0 conceptualisation and implementation.

Transcripts and notes for FGDs and document analysis were developed into a coherent and manageable write – up. FDG generated data were transcribed coded into emergent themes and organised into retrievable sections. Similarities and differences about compiled codes were clustered respectively to create categories. In order to develop well refined categories to best capture different data, re – coding was done until saturation was reached. Saturation implied no new data could be generated, and therefore no new categories could be formed (Baškarada, 2014). Subsequently, data were interpreted guided by the interpretivist paradigm which ontologically and epistemologically acknowledges multiple realities. Therefore meaning attached to data was not prescribed, but derived from emerging themes, and verbatim in relation to Education 5.0 policy documents which provided the curriculum innovation implementation framework. By eliminating identifying information, we were able to protect participants' privacy throughout data presentation and analysis without diminishing the depth of our descriptions (Ponelis, 2015).

## RESULTS

### Diverse education 5.0 ontologies

Education 5.0 higher and tertiary education in Zimbabwe should involve teaching, research and community service focusing on innovation and industrialisation, to provide goods and services to the nation. Therefore higher and tertiary education should produce graduates who are productive in the labour market (MHTESTD, 2019). However, analysis of data from this study shows diverse ontologies (nature of reality) or interpretations of Education 5.0 by science and mathematics teacher educators at the three pre – service teachers' colleges. For instance when asked what Education 5.0 meant, one science teacher educator said:

> It means being involved in projects both lecturers and student teachers so that society benefits. Also the projects generate money which can increase income for those participating in the projects.

Asked how these projects were related to the preparation of pre – service science teachers to effectively facilitate learning science the science teacher educator said:

> Here the innovation part and industrial part of Education 5.0 is catered for when doing projects. The issues of science content and how to teach science are dealt with during science lectures.

These responses reflect lack of understanding of the link between Education 5.0 with the mandate of preparing pre – service science teachers who are Education 5.0 compliant in relation to teaching and learning in school they will teach.
Another science teacher educator when asked how Education 5.0 was being implemented said:

> We have done quite a lot. For instance we are producing soap, dish washers and candles and we are making a lot of money. This money is shared among members in the project and it helps to improve salaries of members.

Asked how this helps pre – service science teachers to be Education 5.0 compliant when they graduate the science teacher educator went on to say:

> The syllabuses have been revised to ensure that preparation of pre – service science teachers is Education 5.0 compliant.

Education 5.0 curriculum innovation as a concept was understood differently by science and mathematics teacher educators. For instance one science teacher educator said:

> Education 5.0 means making something new, like a working gadget for science teaching.

Asked to show the link or nexus of innovation with Education 5.0 which seeks to cause industrialisation the response was:

> Pre – service science teachers develop skills to make goods which can benefit society.

Asked whether this could lead to industrialisation the science teacher educator said with doubt clearly evident through facial expression:

> Yaa –ah, I think so. I am not clear how pre – service science teachers we produce can directly cause industries to develop to cause industrialisation.

Linking Education 5.0 with community service and pre – service science teacher preparation one mathematics teacher educator said:

> Pre – service science teachers will help people to start projects like making soap and dish washers in the communities they will teach. They will use skills learnt while at college.

Asked to elaborate how this would cause industrialisation the response was:

> Products like soap made by pre – service teachers for the community are just like those made in industry. So in a way we can say it's similar to industrialisation.

These responses basically show various ontologies about Education 5.0 and how innovation and industrialisation should occur. Various conceptions of Education 5.0 and related issues exhibited by science and mathematics teacher educators seemed to emanate from factors discussed below which include information dissemination, availability of resources and expected benefits from the implementation.

**Information dissemination**

In line with vision 2030 the National Development Strategy 1 (NDS1) document guides the development trajectory Zimbabwe should take until 2025 (Government of Zimbabwe, 2020). NDS 1 explains how Zimbabwe should move towards vision 2030 of being an upper middle economy, through creation of a knowledge economy for sustained growth, and innovation for industrialisation. Drivers of NDS 1 are human capital development and innovation. This calls for reconfiguration of the education system with a strong emphasis on Science, Technology, Engineering, Arts and Mathematics (STEAM) (Government of Zimbabwe, 2020).

Therefore higher and tertiary education provisions should be framed and guided by NDS1. Also other policy documents which guide higher and tertiary education in Zimbabwe are Doctrine Education 5.0 (GoZ, n.d), Zimbabwe National Critical Skills Audit (ZNCSA) (MHTESTD, 2018), and the Zimbabwe National Qualifications Framework (ZNQF) (MHTESTD, 2018). In line with Education 5.0 these policy documents give a policy framework which guides production of goods and services, which imply teacher education institutions should prepare pre – service teachers who are effective in producing STEAM compliant secondary school graduates. In pre – service science teacher preparation, science educators should be well versed with interpretation of these policy documents, for them to interpret and implement Education 5.0 within context. However, findings of this study reveal that science and mathematics educators had a vague awareness of the existence of these important policy documents, let alone their interpretation and implementation. For instance one FGD science teacher educator said:

> I have heard about NDS 1 at a workshop but I have not read it, or seen it. Such documents should be made available.

Also when FGD science and mathematics teacher educators were asked to identify other Education 5.0 policy documents and what their thrust was, one mathematics educator whose response concurred with others said:

> There are no other documents that we were given apart from workshop notes and reference to Education 5.0 during staff briefings. If we could get the documents and discuss them in workshops I think it can help us to understand Education 5.0.

Facial expressions of science and mathematics teacher educators in this FDG seemed to confirm lack of awareness of the existence of Education 5.0 policy documents as expressed in the response given by their colleague. However, what is surprising about the responses by these science and mathematics educators is that National Development Strategy1 (NDS1) is available on the MHTESTD website and readily available to download for reading. Other documents unknown to science and mathematics educators relevant to the implementation of Education 5.0 and available on the MHTESTD website, are ZNCSA, and (ZNQF. This lack of awareness of the existence of these Education 5.0 linked documents by science and mathematics educators suggests a gap in the implementation of the Education 5.0 curriculum innovation. This raises questions on how one can religiously implement Education 5.0 without the prerequisite knowledge.

**Availability of resources**

While science teacher educators reflected some deficiencies in understanding and interpreting Education 5.0 and its implementation, but their responses revealed that some resources for Education 5.0 teaching and learning were available as outlined in the policy documents.

For instance one mathematics teacher educator said:

> Relatively apparatus are available to do problem solving tasks and investigations that can equip pre – service teachers with skills to teach effectively in schools.

This view was supported by science teacher educators as summarised by one of them saying:

> Apparatus and materials for teaching ICTs and internet are available, so pre – service science teacher develop 21st century ICT competencies.

Concurring with the immediately preceding response another science teacher educator said:

> While resources like funding for apparatus are available, but there is need for improved remuneration for science educators. In fact educators in general, not only at this teachers' college but all teachers' colleges salaries should improve. This demotivates and cause lack of trust and commitment to implement the programme Education 5.0.

With respect to remuneration corroborating views given by other FGD participants, one mathematics teacher educator pointed out that:

> Salaries for lecturers should be improved. Broadly speaking there is a genuine need for salaries of all college lecturers to be increased.

This shows that in addition to making material resources for implementation of the innovation, the welfare of teacher educators should be looked into, to address issues of their welfare concern.

**Recruitment of prospective science and mathematics teachers**

Having prospective science teachers with high competences in science content knowledge is a critical determinant of the quality of pre – service science teachers that will be produced. During a zoom workshop one science teacher educator commented:

> The challenge present is to attract prospective pre – service science teachers who have high passes in science subjects. This implies those who are recruited to train as science and mathematics teachers have average passes hence low science content knowledge at entry point.

Although this was not part of data gathering plan, but relevance of the zoom workshop made it appropriate to include data from the workshop into this study. This is consistent with qualitative research which allows methodology to be modified during data collection.

During FGD discussions sentiments of low uptake of pure sciences at secondary school level was mentioned as the reason why few students enrolled as pre – science teachers. For instance one FGD mathematics teacher educator said in agreement with other participants:

> Few pupils at secondary school level are doing science subjects like Biology, Physical Science, Physics and Chemistry. Many do the less demanding Integrated Science.

Similarly another science teacher educator FGD participant said:

> At advanced level very few student do physics, chemistry, mathematics and biology. Especially physics is done by few students.

These responses show that there are very few secondary school science and mathematics graduates, such that higher and tertiary education institutions end up competing to enroll even those prospective science and mathematics teachers with low passes.

**Expected benefits from curriculum innovation implementation**

Any curriculum innovation implementation has benefits anticipated by implementers as per promise by the curriculum innovation developers and policy makers (MHTESTD, 2019). Some of the anticipated benefits as expressed in the Zimbabwe Manpower Planning and Development Act Amendment No. 2020 are:

- Correct placement of college lecturers into grades and appropriate remuneration.
- Self – regulation afforded to college lecturers as they are freed from the limiting Civil Service framework. This will enable college lecturers to have autonomy in focusing on high quality innovative curriculum implementation to produce 21st century pre – service science teachers.

Commenting on these expected benefits from the implementation of Education 5.0 one science teacher educators said:

> Being placed in the proper salary structure is good news because it causes me to be committed to work with the view to effectively implement Education 5.0. I feel recognised for commitment to hard work to achieve the aim of preparing science teachers for national development agenda. However, it is disappointing that this change is taking too long than we expected it to happen. May be it will never happen.

Another science teacher educator said:

> It demotivates to know that the salary you get is not different from that of those you train soon after graduating. If this happens it will truly boost morale of not only of science educators, but all educators.

These responses show that the issue of proper remuneration is critically important to the success of curriculum innovation implementation. Implementing an innovation may sound plausible, but limitations (Leung, 2022), like low motivation of implementers, in this case science and mathematics educators, adversely affect successful implementation.

## DISCUSSION

Based on the analysis of documents which include Zimbabwe National Critical Skills Audit (MHTESTD, 2018), Doctrine Education 5.0 (GoZ, n.d), MHTESTD 2019 – 2023 Strategic Plan (MHTESTD, 2019), Education 3.0 whose three components are teaching, research and community service changed to Education 5.0 with five components which are teaching, research, innovation, community service, and industrialisation (Murwira, 2019). Therefore precisely Education 5.0 is a broad MHTESTD curriculum innovation which is referred to in this discussion as Education 5.0 curriculum innovation. The fact that some participants viewed Education 5.0 curriculum innovation as relevant in responding to the socio – economic needs of Zimbabwe, implies that chances are high that it can be implemented with success. In addition to willingness to implement, science and mathematics educators should understand Education 5.0 curriculum innovation implementation consistent with teacher education institutions mandate of producing pre – service science and mathematics teachers who in turn have the capacity to produce secondary school graduates with exit competences to innovate, join industry, do STEM related carriers, as well as pursuing science, technology, engineering and mathematics up to university level (Adams et al., 2014; Aina, 2014). Therefore curriculum innovation implementation should be configured to exploit the willingness or voluntary buy in science and mathematics educators exhibited, to genuinely participate in implementation.

Diverse interpretations or ontologies about Education 5.0 curriculum innovation exhibited by science and mathematics teacher educators threaten its successful implementation in the 3 teachers' colleges. For instance, some science and mathematics educators viewed Education 5.0 as focused on provision of goods and services, like engaging in soap making projects, while some viewed it as innovation of instruction in teacher education. However, the science educators could not explicitly show methodolodically how these "innovative" projects and instruction would subsequently lead to industrialisation as envisaged by Education 5.0. It is noteworthy that science and mathematics teacher educators could also not show how the projects would prepare pre – service science teachers as expected by the Ministry of Primary and Secondary Education (MoPSE), which employs most of the science and mathematics teachers in Zimbabwe. This lack of clarity comes as no surprise, since any innovation is complex and multifaceted (Kogabayev & Maziliauskas, 2017), with no agreed definition. Ensuring science and mathematics teacher educators have a common accurate understanding or ontology about Education 5.0 curriculum innovation implementation, through dissemination of information may ensure successful implementation. The definition of innovation being contested ground (Nicolaides, 2014), points to the need for innovation developers to ensure that their innovation is understood by the implementers and implemented in the manner intended.

Education 5.0 curriculum innovation diverse interpretations imply the Ministry of Higher and Tertiary Education system, MHTESTD as the curriculum innovation developer should provide a contextual operational definition. This would ensure that a common understanding is developed and implementation would occur as intended. Education 5.0 is a generic curriculum innovation characterised by change in policy as defined by policy documents. Education 5.0 comprises five components which are teaching, research, innovation, community service, and industrialisation, and innovation is the link among the other four components. Therefore congruous with institutional mandate, innovation should be contextualised in all departments of respective higher and tertiary education institutions. Consistent with Education 5.0, teacher education institutions should have their teaching, research and community service informed by innovation. This implies innovative approaches used in teaching, research and community service should ensure that pre – service science teachers are equipped with exit competences which enable them to produce secondary school science and mathematics graduates who are ready to participate in various socio – economic sectors as well as pursuing various industry related carriers. What should be crystal clear is that the manner in which curriculum innovation is implemented should not deviate from the mandate of the institution or department of the institution. For instance, the Education 5.0 innovative approaches used at the school of medicine cannot be the same with those used at the school of Law, school of business studies, a vocational technical college, polytechnic, rehabilitation centre or secondary teachers' college training science teachers. Education 5.0 as an innovation should be implemented in all institutions of higher and tertiary education, but as per mandate of each institution rather than through an all size fits all approach.

Information dissemination is critical to success in implementation of an innovation. In this context the philosophy of Education 5.0 curriculum innovation should be well communicated comprehensively by explaining and making available to stakeholders, key policy documents like the National Development Strategy 1 (NDS1), Doctrine Education 5.0, Zimbabwe National Skills Audit and Zimbabwe National Qualification Framework

(ZNQF), which constitute the implementation framework. Important stakeholders in the implementation of Education 5.0 curriculum innovation are teacher educators in teacher education preparation institutions (colleges and universities). The fact that science and mathematics teacher educators involved in the study where not conversant with key policy documents, and how they are related to Education 5.0 curriculum innovation implementation, implies existence of a gap in communication on issues concerning Education 5.0 curriculum innovation implementation. Therefore there is need for effective communication and feedback mechanisms to promote sharing of information (Bawakyillenuo et al., 2013; Mandasari et al., 2021), among science and mathematics teacher educators, pre – service science and mathematics teachers, Ministry of Primary and Secondary Education, Ministry of Higher and Tertiary Education, Science and Technology Development, and industry, as stakeholders. Sharing of such information enables stakeholders to have a common vision of implementation of Education 5.0 curriculum innovation which will act as a premise for informed decision making and implementation.

Prospective science and mathematics teachers should have high qualifications at entry point, in line with rigorous innovative measures which should be taken to improve pre – service science teacher preparation (Polgampala et al., 2016). From the beginning of the recruitment process, prospective science and mathematics instructors should be subjected to a rigorous selection procedure before being admitted to pre-service preparation. This study revealed, however, that science and mathematics enrollment at the secondary school advanced level (A-Level) is relatively low. Therefore, the Ministry of Public and Private Education should implement mechanisms to increase enrollment in A-Level science and mathematics subjects in order to increase the number of prospective science and mathematics teachers with advanced degrees. The transition from pre-service teacher education to continued professional development for science and mathematics teachers should be founded on a consistent, systematic, and ongoing system that enables science teachers to remain apprised of evolving educational innovations. The model for science teacher education should be responsive, yet stable, inclusive, targeted, specialized, and adaptable (Tan, 2018).

Preparing high quality science and mathematics teachers is a priority as expressed by the Science and Technology Policy of 2012 of the Ministry of Higher and Tertiary Education, Innovation, Science and Technology Development (MHTEISTD), which states the minimum qualification of science and mathematics teachers as a first degree (Ministry of Science and Technology Development, 2012). Buttressing the need to prepare high quality teachers is the Ministry of Primary and Secondary Education (MoPSE) of Zimbabwe's thrust that every teacher should have a first degree as the minimum qualification (MoPSE, 2015). MoPSE is the main employer of pre – service teachers produced by MHTESTD, through teachers' colleges and universities. Pre – service science and mathematics teachers with such qualifications will spearhead socio – economic development by producing Education 5.0 compliant secondary school graduates, who are ready to join various Zimbabwean socio – economic development sectors. Therefore in this context, the continued production of pre – service teachers who are Diploma holders is incongruous with policy thrust (MoPSE, 2015; MSTD, 2012) for manpower development. This indicates the need to align qualifications teachers get with current policies, so that the effort to achieve sustainable industrialisation in the 21st century and beyond is supported (MoPSE, 2015; MSTD, 2012).

Remunerating science and mathematics teacher educators well was shown by this study to be a strong indicator of motivation and support to human capital for successful curriculum innovation implementation. Although science and mathematics educators applauded the intent of Education 5.0 curriculum innovation to place them in their correct remuneration bracket comparable with regional standards, they lamented the implementation process for moving at snail pace. They expressed reservations on whether they would benefit as portrayed in the Doctrine Education 5.0 and the Manpower Planning and Development Amendment Act (Government of Zimbabwe, 2021). This shows that if questionable effort is put into ensuring curriculum innovation implementers receive envisaged benefits, then curriculum innovation implementation may not be done with fidelity or religiously, which threatens successful implementation. Strictly speaking failing to afford expected benefits as intended by the curriculum innovation at its inception, is a negation of successful implementation which results in failure to achieve intended goals.

## CONCLUSION

There is an umbilical connectedness between diverse ontologies about what an innovation is, and how it should be implemented. If not accurately guided, implementers will implement the curriculum innovation in line with individual ontologies. Since innovation is a contested concept there is need for curriculum innovation developers to ensure that implementers are helped to understand in no uncertain terms what needs to be innovated and how. The object of curriculum innovation should be crystal clear, otherwise if clarity is a missing link, then success of curriculum innovation implementation will be under threat of failure emanating from diverse ontologies or interpretations of the innovation and its implementation.

Provision of goods and services through Education 5.0 in science and mathematics teacher education should be understood in the context of the mandate to develop human capital, relevant to socio – economic needs of Zimbabwe. The ultimate goods and services Education 5.0 curriculum innovation implementation should achieve is producing pre – service science and mathematics teachers who are capable of equipping secondary school graduates with the prerequisite industry linked STI competences.

Internationally a holistic socio – economic development, through aligning tertiary education with needs of the economy has been acknowledged as an effective paradigm. Creation of knowledge based economies by situating higher education and training at the centre of development, has made countries like China, the Asian Tigers ( South Korea, Taiwan, Singapore, Malaysia) and Brazil, the fastest growing economies in the world. However, making reference through policy documents to success stories of these nations, and others like Japan, US, Britain and Australia to give credence to the view being presented is one thing (theoretical / academic), and creating enabling conditions or environment for success of the innovation is another (practical). It is important to note that critical to the success of countries which are made reference to, is development of policies, enactment of laws and creation of conducive environments in which higher education – industry linkages thrived. This suggests that countries that wish to follow a similar successful development trajectory should invest in higher education, and develop policies that reposition human capital development at the centre of their developmental agenda. Practically, Curriculum innovation implementation success needs more than well written documents, hence policy makers should create conducive environments with well looked after appropriate manpower to translate the envisaged innovation into reality by achieving set goals.

## REFERENCES


Adams, A. E., Miller, B. G., Saul, M., & Pegg, J. (2014). Supporting elementary pre-service teachers to teach STEM through place-based teaching and learning experiences. *The Electronic Journal for Research in Science & Mathematics Education*, *18*(5), 1–22. https://ejrsme.icrsme.com/article/view/12958

Aina, J. K. (2014). Pre-service science teachers' training: The case of colleges of education in Nigeria. *Open Access Library Journal*, *1*(8), 1–6. https://doi.org/10.4236/oalib.1101070

Akhtar, S. (2018). Innovations in teacher education curriculum, curriculum design. *International Journal of Technical Research and Science*, *1*(12), 858–861.

Akpan, B. B. (2010). Innovations in science and technology education through science teacher associations. *Science Education International*, *21*(2), 67–79. https://icaseonline.net/sei/june2010/p1_Ben_Akpan.pdf

Barakabitze, A. A., William-Andey Lazaro, A., Ainea, N., Mkwizu, M. H., Maziku, H., Matofali, A. X., Iddi, A., & Sanga, C. (2019). Transforming African education systems in Science, Technology, Engineering, and Mathematics (STEM) Using ICTs: Challenges and opportunities. *Education Research International*, *2019*, 1–29. https://doi.org/10.1155/2019/6946809

Baškarada, S. (2014). Qualitative Case Study Guidelines. *The Qualitative Report*, *19*(24), 1–18. https://doi.org/10.46743/2160-3715/2014.1008

Bawakyillenuo, S., Akoto, O. I., Ahiadeke, C., Aryeetey, B. E., & Agbe, K. E. (2013). *Tertiary education and industrial development in Ghana*. https://www.theigc.org/wp-content/uploads/2015/02/Bawakyillenuo-Et-Al-2013-Working-Paper.pdf

Chandio, A. R. (2021). Evaluating ICT utilization in education administration and management during the COVID-19 outbreak in Pakistan: An empirical review. *Journal of Research in Instructional*, *1*(2), 81–94. https://doi.org/10.30862/jri.v1i2.15

Chingozha, M. P., Ruvengo, L., Mapindu, I., & Shava, G. (2022). Restructuring higher education to axhieve quality and innovation: A Review of literatue. *Journal of Current Egineering and Technology*, *4*(1), 1–8. https://doi.org/10.36266/JCET/153

Chitate, H. (2016). Science, Technology, Engineering and Mathematics (STEM): A Case study of Zimbabwe's educational approach to industrialisation. *World Journal of Education*, *6*(5), 27–35. https://doi.org/10.5430/wje.v6n5p27

Deng, Z. (2010). Curriculum transformation in the era of reform initiatives: The need to rethink and re-conceptualize content. *Journal of Textbook Research*, *3*(2), 93–113. http://ej.naer.edu.tw/JTR/v03.2/J06v03n02.pdf#page=101

Docherty-Skippen, S. M., Karrow, D., & Ahmed, G. (2020). Doing science: Pre-service teachers' attitudes and confidence teaching elementary science and technology. *Brock Education Journal*, *29*(1), 24. https://doi.org/10.26522/brocked.v29i1.768

Dziwa, D. D., & Postma, L. (2020). Building creative capacities through art teacher education in Zimbabwe. In N. Popov, C. Wolhuter, L. de Beer, G. Hilton, J. Ogunleye, E. Achinewhu-Nworgu, & E. Niemczyk (Eds.), *BCES Conference Books* (Vol. 18, pp. 277–283). Bulgarian Comparative Education Society. https://bces-conference.org/onewebmedia/2020.277-283.Dairai.Dziwa_Louise.Postma.pdf

Gouëdard, P., Pont, B., & Huang, S, H. P. (2020). *Curriculum reform: A literature review to support effective implementation* (No. 239). https://www.oecd-ilibrary.org/docserver/efe8a48c-en.pdf?expires=1686407025&id=id&accname=guest&checksum=726E5A2D647E012203EE5859EE7BFA9F

Government of Zimbabwe. (2020). *National Development Strategy 1 (NDS1)*. https://www.dpcorp.co.zw/assets/national-development-strategy-1_2021---2025_goz.pdf

Government of Zimbabwe. (2021). *Manpower planning and development amendment act, 2020*. https://gazettes.africa/archive/zw/2021/zw-government-gazette-dated-2021-05-07-no-56.pdf

Government of Zimbabwe (GoZ) (n.d). Doctrine educationn 5.0, GoZ, https://library.buse.ac.zw/docs/gvt-publications/higher-edu-plan.pdf

Habiyaremye, A., King, N., & Tregenna, F. (2022). *Innovation and socio – economic sevelopment challenges in South Africa: An overview of indicators and trends* (SARChl Industrial Development Working Paper Seies 2022-03). https://www.uj.ac.za/wp-content/uploads/2021/10/sarchi-wp-2022-03-habiyaremye-king-tregenna-march-2022.pdf

Im, S., Yoon, H.-G., & Cha, J. (2016). Pre-service Science teacher education system in South Korea: Prospects and challenges. *EURASIA Journal of Mathematics, Science and Technology Education*, *12*(7), 1863–1880. https://doi.org/10.12973/eurasia.2016.1533a

Kogabayev, T., & Maziliauskas, A. (2017). The definition and classification of innovation. *HOLISTICA – Journal of Business and Public Administration*, *8*(1), 59–72. https://doi.org/10.1515/hjbpa-2017-0005

Kotsemir, M., Abroskin, A., & Dirk, M. (2013). *Innovation concepts and typology: An evolutionary discussion*. https://mpra.ub.uni-muenchen.de/45069/1/MPRA_paper_45069.pdf

Labinjoh, J. (1975). Book reviews : Class, culture and the curriculum. By Denis Lawton (London, Routledge & Kegan Paul, 1975). £1.50. Paper. *Race & Class*, *17*(2), 217–217. https://doi.org/10.1177/030639687501700218

Lelasari, T., Yohanita, A. M., & Damopolii, I. (2021). Effect of inquiry science learning on students' metacognitive skill. *Journal of Research in Instructional*, *1*(1), 53–60. https://doi.org/10.30862/jri.v1i1.12

Leung, J. S. C. (2022). Shifting the teaching beliefs of preservice science teachers about socioscientific issues in a teacher education course. *International Journal of Science and Mathematics Education*, *20*(4), 659–682. https://doi.org/10.1007/s10763-021-10177-y

Mandasari, F., Iwan, I., & Damopolii, I. (2021). The relationship between science process skills and biology learning outcome. *Journal of Research in Instructional*, *1*(1), 23–32. https://doi.org/10.30862/jri.v1i1.9

Mazzucato, M. (2018). Mission-oriented innovation policies: Challenges and opportunities.

*Industrial and Corporate Change*, *27*(5), 803–815. https://doi.org/10.1093/icc/dty034

Ministry of Higher and Tertiary Education Science and Technology Development. (2018a). *Zimbabwe National Critical Skills Audit Report (ZNCSA)*. http://www.mhtestd.gov.zw/?p=3501

Ministry of Higher and Tertiary Education Science and Technology Development. (2018b). *Zimbabwe National Qualifications Framework (ZNQF).* http://www.mhtestd.gov.zw/?p=3501

Ministry of Higher and Tertiary Education Science and Technology Development. (2019). *Strategic Plan 2019-2023: The Doctrine, Modernisation and Industrialisation of Zimbabwe*. Government of Zimbabwe. http://www.mhtestd.gov.zw/?p=3501

Ministry of Primary and Secondary Education of Zimbabwe (MoPSE), (2015). *Curriculum Framework for Primary and Secondary Education 2015 - 2022*, MoPSE. http://mopse.co.zw/sites/default/files/public/downloads/Zim_Curriculum_Framework.pdf

Ministry of Science and Technology Development. (2012). *Second science, technology and innovation policy of Zimbabwe*. https://healthresearchwebafrica.org.za/files/Zimbawesciencetechpolicydocumentnew.pdf

Mohd Zawawi, N. F., Abd Wahab, S., Al-Mamun, A., Sofian Yaacob, A., Kumar AL Samy, N., & Ali Fazal, S. (2016). Defining the concept of innovation and firm innovativeness: A critical analysis from resorce-based view perspective. *International Journal of Business and Management*, *11*(6), 87–94. https://doi.org/10.5539/ijbm.v11n6p87

Murwira, A. (2019). *Towards revitalising the Roles of Universities in Development in Zimbabwe*. https://www.ruforum.org/AGM2019/sites/default/files/HON_MINISTER_PROF_MURWIRA_SPEECH.pdf

Nakedi, M., Taylor, D., Mundalamo, F., Rollnick, M., & Mokeleche, M. (2012). The story of a physical science curriculum: transformation or transmutation? *African Journal of Research in Mathematics, Science and Technology Education*, *16*(3), 273–288. https://doi.org/10.1080/10288457.2012.10740745

Nicolaides, A. (2014). Research and Innovation--the drivers of economic development. *African Jpurnal of Hospitality, Tourism and Leisure*, *3*(2), 1–16. https://www.ajhtl.com/uploads/7/1/6/3/7163688/article_9_vol.3_2_july.pdf

Nusantari, E., Utina, R., Katili, A. S., Tamu, Y., & Damopolii, I. (2020). Effectiveness of environmentally-based science learning towards environmentally-friendly character of students in coastal area. *International Journal of Instruction*, *13*(3), 233–246. https://doi.org/10.29333/iji.2020.13316a

OECD. (2008). *Tertiary Education for the Knowledge Society. OECD thematic review of tertiary education: Synthesis report.* https://www.oecd.org/education/skills-beyond-school/40345176.pdf

OECD, & International Development Research Centre. (2010). *Innovation and the development agenda* (E. Kraemer-Mbula & W. Wamae (eds.)). https://doi.org/10.1787/9789264088924-en

Ogunniyi, B. M. and Rollnick, M, (2015). Pre - service Science Teacher Education in Africa:

Prospects and Challenges. Journal of Science Teacher Education, 25(1), 65 - 79 https://www.jstor.org/stable/43670619

Polgampala, A. S. V., Shen, H., & Huang, F. (2016). Where we are and where we need to be: pre service science teacher preparation in China \& Sri Lanka. *American Journal of Educational Research*, *4*(16), 1138–1144. https://doi.org/10.12691/education-4-16-3

Ponelis, S. R. (2015). Using Interpretive qualitative case studies for exploratory research in doctoral studies: A case of information systems research in small and medium enterprises. *International Journal of Doctoral Studies*, *10*, 535–550. https://doi.org/10.28945/2339

Superfine, A. C., Marshall, A. M., & Kelso, C. (2015). Fidelity of implementation: bringing written curriculum materials into the equation. *The Curriculum Journal*, *26*(1), 164–191. https://doi.org/10.1080/09585176.2014.990910

Tan, A.-L. (2018). Journey of science teacher education in Singapore: past, present and future. *Asia-Pacific Science Education*, *4*(1), 1–16. https://doi.org/10.1186/s41029-017-0018-8

Taylor, S. P. (2017). What Is innovation? A Study of the definitions, academic models and applicability of innovation to an example of social housing in England. *Open Journal of Social Sciences*, *05*(11), 128–146. https://doi.org/10.4236/jss.2017.511010

United Nations Conference on Trade and Development. (2019). *Module 1: Innovation, Policy and Development Course Content*. https://unctad.org/system/files/official-document/dtlstictinf2019d1_en.pdf

World Bank. (2003). *Lifelong learning in the global knowledge economy: Challenges for developing countries*. https://elibrary.worldbank.org/doi/abs/10.1596/978-0-8213-5475-9

World Bank. (2019). *The World Bank in China*. https://www.worldbank.org/en/country/china/overview

Wu, W. (2007). Building research universities for knowledge transfer: the case of China. In S. Yusuf & N. K. (Eds.), *How universities promote economic growth*. World Bank. https://openknowledge.worldbank.org/server/api/core/bitstreams/fb7d2b4f-0a9a-5268-97f2-fde831e8a588/content

Wuta, K. R. (2022). Extendibility of the Education 5.0 Concept to Zimbabwe's Secondary School System as Encapsulated in Curriculum Frame 2015 – 2022. *Indiana Journal of Humanities and Social Sciences*, *3*(5), 26–33. ttps://indianapublications.com/articles/IJHSS_3(5)_26-33_6295e4086e9c02.04596410.pdf