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Secondary mathematics education in South Africa and Zimbabwe: Learning from one another

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ABSTRACT

This comparative research examines secondary school mathematics education systems in South Africa and Zimbabwe. Data were gathered through the examination of mathematics curriculum policy documents, syllabi, exam papers, research reports, and the author's personal experiences. The findings suggest that both countries can learn from one another. Lessons for South Africa include increasing the time and pass mark for mathematics exams, as well as spreading continuous assessment over a longer period of time. South Africa may possibly reduce the number of subjects offered in grades 11 and 12 to allow learners more time to study mathematics. Redesigning question papers to include optional questions for learners could also be beneficial. Lessons for Zimbabwe include increasing mathematics education resources and mandating mathematics for all advanced level candidates. Zimbabwe may also conduct trial examinations and hire mathematics curriculum advisors to assist mathematics teachers in schools on a regular basis.

Keywords: mathematics education, secondary school, continuous assessment, curriculum, mathematics stream

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INTRODUCTION

South Africa and Zimbabwe are neighboring states in Southern Africa that share a border. South Africa is located in the southernmost point of the African continent, while Zimbabwe is landlocked between South Africa and Zambia. South Africa was previously colonized by the Dutch and the British, whereas Zimbabwe was colonized by the British. Zimbabwe gained independence in 1980, 14 years before South Africa, which did so in 1994. Since then, both countries' education systems have undergone various curriculum modifications in an attempt to correct the inequities caused by the colonial education system. To contextualize the study, we examine the two countries' mathematics education developments to date.

Mathematics Education Reforms in South Africa

South African mathematics curriculum revisions have largely focused on enhancing access to mathematics education for previously disadvantaged groups. Prior to 2006, mathematics in South Africa was only compulsory up to the ninth grade level. It was optional in further education and training (FET) band (grades 10-12). Those who decided to study mathematics in the FET band could do so at the standard or higher grade level. The 2007 cohort of grade 12 learners was the last group to write mathematics at either the higher or standard level.

Curriculum 2005 (C2005), an outcomes-based education (OBE) for learners in grades R-9, was introduced by Department of Education in 1998 (Taylor, 2012). This was scheduled to be fully implemented throughout all grade levels by 2005. The goal of OBE was to replace traditional content-based education with a learner-centred outcomes-based teaching and learning approach that could be applied across all subjects, including mathematics (Department of Education, 2001). OBE changed the focus of mathematics teaching and learning away from mathematical content toward the learning process and learning outcomes (Department of Education, 2002). The apartheid curriculum was accused of being overly content-heavy and of encouraging memorizing (Department of Education, 2001). OBE required learners to apply what they had learned in order to achieve the desired outcomes. C2005 policy statement simply outlined the broad topics that must be taught in mathematics across all grade levels, accompanied by a plethora of expected outcome statements. It was non-prescriptive, open, and relied on teachers to develop their own learning programs and learning support resources (Department of Education, 2002; Schmidt, 2017). This posed serious challenges in mathematics teaching and learning in Taylor General Education and Training (GET) band (grades 7-9). It was highly vague in terms of what content was expected to be taught in different grades, at what pace and order, and how it should be assessed (Jansen, 1998; Rensburg, 2009). In addition, poor schools lacked the resources needed to teach mathematics the OBE way (Schmidt, 2017).

Department of Education commissioned a review of the C2005 in the year 2000. This resulted in the second edition of OBE: revised national curriculum statement (RNCS) for grades R-9, which was adopted in 2002 (Department of Education, 2002). This new policy statement tried to solve some of C2005's difficulties by decreasing learning outcomes and providing direction on evaluation standards (Department of Education, 2002). However, RNCS encountered the same implementation issues as C2005. Teachers were inadequately trained (Christie, 1999; Schmidt, 2017) and the revised curriculum policy statement still used ambiguous, convoluted terminology that teachers struggled to understand. It was still unclear what had to be taught and in what order (Rensburg, 2009). Teachers could not tell the difference between C2005 and the RNCS. Learners' mathematics performance remained dismal, necessitating another review of the curriculum (Aldous-Mycock, 2009).

For the first time in 2006, all South African learners were expected to do either mathematics or mathematical literacy in FET band (Sidiropoulos, 2008). This was due to a new national curriculum statement that mandated that all learners in grades 10 through 12 should do some form of mathematics (Sidiropoulos, 2008). Mathematical literacy is a completely separate subject from pure mathematics. It focuses on solving real-world problems in various circumstances using basic mathematical operations (addition, subtraction, multiplication and division). Mathematical literacy was provided as an option for learners who were unable to do mathematics throughout FET period. Apartheid left a society with unacceptable low levels of numeracy and achievement as a consequence of its inequitable allocation of educational resources and access to mathematics (Sidiropoulos, 2008). As a result, the democratic government created this two-pronged mathematics curriculum to address these long-standing imbalances. In addition to making mathematics compulsory, the RNCS for FET band mathematics removed Euclidean geometry from the core mathematics curriculum and relegated it to an optional paper–mathematics paper 3 (Machisi, 2020). This was due to the fact that most teachers found it difficult to teach and that it was reportedly causing a high failure rate in mathematics.

A series of studies involving first-year university students done between 2009 and 2011 revealed that students who had not studied Euclidean geometry in high school had lower mathematical skills than their counterparts who had. Academics at several South African universities then urged that Euclidean geometry be reintroduced into the mainstream mathematics curriculum. This led to the unveiling of a new mathematics curriculum, curriculum and assessment policy statement (CAPS) for mathematics grades 10-12, in January 2012. In CAPS, linear programming was replaced by probability in mathematics paper 1, and transformational geometry was replaced by Euclidean geometry in mathematics paper 2. Unlike earlier mathematics curriculum pronouncements, CAPS specifies what must be taught in each topic, as well as the sequence, pacing, formal tasks to be administered, and mark weighting. However, the assessment of learners' performance in CAPS is still 25% continuous assessment and 75% exam, with a minimum aggregate pass mark of 30%.

The introduction of technical mathematics in grade 10 at technical schools in 2016 indicates that curriculum change is a continuous process. We are therefore likely to see more curriculum reforms as we strive to keep up with global trends and new developments in mathematics education research. South Africa has made significant progress in attempting to correct past disparities and ensure that all learners, regardless of race, color, or gender, have equitable access to learning mathematics. The following section examines the progress made in mathematics education in Zimbabwe.

Mathematics Education Reforms in Zimbabwe

In contrast to South Africa, which began curriculum reforms quickly after independence, Zimbabwe took more than two decades to enact curriculum revisions. British Cambridge international examinations (CIE) curriculum was inherited by the new democratic government in 1980. It gave national examinations and certifications at grade 7, form 2 (junior certificate), form 4 (general certificate of education ordinary level [O-level]), and form 6 (general certificate of education advanced level [A-level]). Mathematics was compulsory up to form 4 (grade 11) and optional for students pursuing A-level studies in this system. A learner needed to get at least 50% on the final exam to pass mathematics at O-level. O-level mathematics scores have been dismal since independence, falling below 30% from 2008 to 2011 (Sunzuma, 2018). As a result of such low performance, the country struggled to meet labor market demands. This prompted Zimbabwe's political leadership to establish Nziramasanga Commission of Inquiry into Education and Training (CIET) in 1998, to investigate the structure and content of education in order to diagnose systemic flaws.

In 1999, CIET team published an invaluable report known as the Nziramasanga report, which advocated a total revamp of the education system. It shifted the education system from an obsolete concentration on knowledge transmission to a competency-oriented curriculum that meets the demands of the twenty-first century (Gory et al., 2021; Ministry of Primary and Secondary Education, 2015a). According to the Nziramasanga assessment, the existing curriculum was excessively academic and did not meet the needs of learners (Gory et al., 2021). It also referred to the high failure rate in mathematics as a disaster. However, due to fiscal restrictions, the country was unable to take significant action on this for nearly 15 years. In 2013, Ministry of Primary and Secondary Education (MoPSE) began nationwide curriculum consultations with stakeholders, which resulted in the publication of the narrative report 2014-2015. Following the acceptance of the revised curriculum in 2015, curriculum framework for primary and secondary education (2015-2022) was published. Its implementation began in 2017 and is expected to be completed by 2022 (Gory et al., 2021).

Mathematics teachers under the former curriculum relied primarily on the Zimbabwe School Examination Council (ZIMSEC) syllabus and prescribed textbooks, with no other teaching guidelines (Sunzuma, 2018). The new curriculum framework lays forth a comprehensive plan for changing the school system across various study areas and grades. It begins with an introduction and background to remind teachers of the reasons for curriculum revision. This is followed by the curriculum's guiding principles, values, and aims. The general learning outcomes in each learning area are then offered, along with recommended teaching and learning strategies. The new curriculum document finishes with assessment guidelines (Ministry of Primary and Secondary Education, 2015a). It is to be used in conjunction with the new mathematics syllabi for the various grades, as well as the prescribed textbooks. The new mathematics syllabus differs from the previous one in that it provides cross-cutting contexts in which topics will be taught, in addition to specifying topics and content for the various grades. Business and finance, disaster and risk management, communication and team building, environmental issues, gender, enterprise, HIV/AIDS, information and communication technology, and humanity are examples of these (Ministry of Primary and Secondary Education, 2015b). It also provides tools and materials that teachers could use

(Ministry of Primary and Secondary Education, 2015b). For the first time in Zimbabwe's educational history, assessments of learner success are no longer only focused on exams (Sunzuma, 2018). Continuous assessment will account for 30% of the final marks, while the exam will account for 70% (Ministry of Primary and Secondary Education, 2015b). The mathematics concepts and content to be taught, on the other hand, remain the same as in the previous curriculum. The sole distinction is the proposed methodology for teaching and assessing learners' performance. The mathematics aggregate pass mark is 50 % (grade C) as was the case in CIE.

Zimbabwe's new curriculum framework is founded on the same premise as South Africa's OBE system. Given that the OBE failed in South Africa, which arguably invests more resources into education than Zimbabwe, one questions if this new curriculum will be beneficial in the light of Zimbabwe's ongoing economic woes. Although the new curriculum looks to have great intentions on paper, its implementation faces serious challenges ranging from a lack of appropriate resources to insufficient in-service teacher training (Gory et al., 2021). In the following section, we discuss the value of international comparative studies.

The Value of International Comparative Studies in Education

International comparative education system studies generate new information of effective educational practices, which leads to policy changes and curriculum improvements in educational systems (Goldstein, 2008; Suter, 2011). The most well-known international comparative studies on education systems are trends in international mathematics and science study (TIMSS), progress in international reading literacy study (PIRLS), and program for international student assessment (PISA). PISA is organized by the Organization for Economic Cooperation and Development (OECD), whilst TIMSS and PIRLS are organized by International Association for Evaluation of Educational Achievement (IEA) (Goldstein, 2008). These studies are funded by the countries that participate in them, and anyone from anywhere in the world can participate. Many countries actively participate in international comparative studies because their governments want to use the comparisons to gauge the performance of their schools, particularly in mathematics and science (Suter, 2011). PISA studies assess 15-year-old students' achievement in language, mathematics, and science in schools. TIMSS studies assess science and mathematics achievement in fourth and eighth grade students, whereas PIRLS studies assess reading literacy in fourth grade students (Goldstein, 2008). Based on students' average scores, the results of these international studies are used to rank countries in a 'league table' from highest to lowest scoring. The countries with the highest performance in mathematics and science tend to be developed, whereas the countries with the lowest performance tend to be poorer, less developed countries (Suter, 2011). Based on the findings of international comparative studies, countries at the bottom of the rankings frequently send a delegation of researchers to the top-performing countries to elicit the secrets of their success (Donnelly, 2014).

Due to differences in cultures, curricula, assessment, socioeconomic level, school organization, and geographical location, critics have questioned the validity of worldwide comparative studies on education such as PISA, TIMSS, and PIRLS (Donnelly, 2014). This is like contrasting apples and oranges (Donnelly, 2014). Furthermore, the performance of an educational system cannot be described by a single measure derived from a brief test (Suter, 2011). There are other more contextual aspects that must be investigated. PISA test, for example, is argued to have a western cultural bias (Gao, 2022), and yet it is also given to non-western countries. Due to the various flaws discovered in international comparative studies, many African countries that used to participate in TIMSS and PIRLS appear to have lost interest in these global comparisons. Algeria, for example, last competed in 2007 (Mullis et al., 2008). Ghana and Tunisia last took part in 2011 (Buabeng et al., 2014). Botswana last took part in 2015 (Mullis et al., 2016), and only Egypt, Morocco, and South Africa did so in 2019 (Mullis et al., 2020). A better comparison would be to compare countries that are geographically close together. As a result, Southern African countries prefer Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ) to TIMSS and PIRLS. SACMEQ analyzes the numeracy and literacy levels of students and teachers in grades 6 across 15 Southern African nations (Hungi et al., 2010). According to the findings of the SACMEQ III project, Zimbabwe, a much poorer country, outperformed South Africa in terms of both literacy and numeracy rates (Hungi et al., 2010). This sparked interest in the current study.

Purpose of the Study

The goal of this research is to compare and contrast secondary school mathematics education in South Africa and Zimbabwe. Furthermore, the study aims to draw lessons for both countries in order to enhance their mathematics education systems.

METHODS

To address the study's purpose, qualitative research methods are used. Qualitative research entails gathering information in the form of words rather than numbers (Busetto et al., 2020; Punch, 2013). Researchers can employ a variety of qualitative methodologies in qualitative research. Document review, interviews, participant and non-participant observation, and focus groups are a few examples. The researcher in this study used document analysis to acquire data that addressed the research aims.

Document Analysis

Any printed or electronic textual information produced by an individual or organization for private or public use is referred to as a document (Kayesa & Shung-King, 2021). The systematic method of skimming, concentrated reading, and evaluating written material in order to identify patterns, develop insights, and draw conclusions about a research phenomenon is known as document analysis (Frey, 2018). It is an iterative technique that includes content analysis and thematic analysis aspects (Bowen, 2009). Document analysis can be used as the primary technique of data collecting or to supplement other ways of data collection (Dalglish et al., 2020). Document analysis is employed in this study as a standalone method. The main advantages of using document analysis as a data gathering strategy are that it is a low-cost, discreet source of information that can provide a backstage view of research phenomena (Morgan, 2022). In addition, it identifies issues that other methods overlook (Morgan, 2022). Unlike people, documents are not reactive to specific features of the data collection process (Bowen, 2009). They can be viewed and read multiple times without the writers' permission (Cardno, 2018). Curriculum policy documents, mathematics syllabi, mathematics textbooks, previous examination papers, and research reports were among the documents

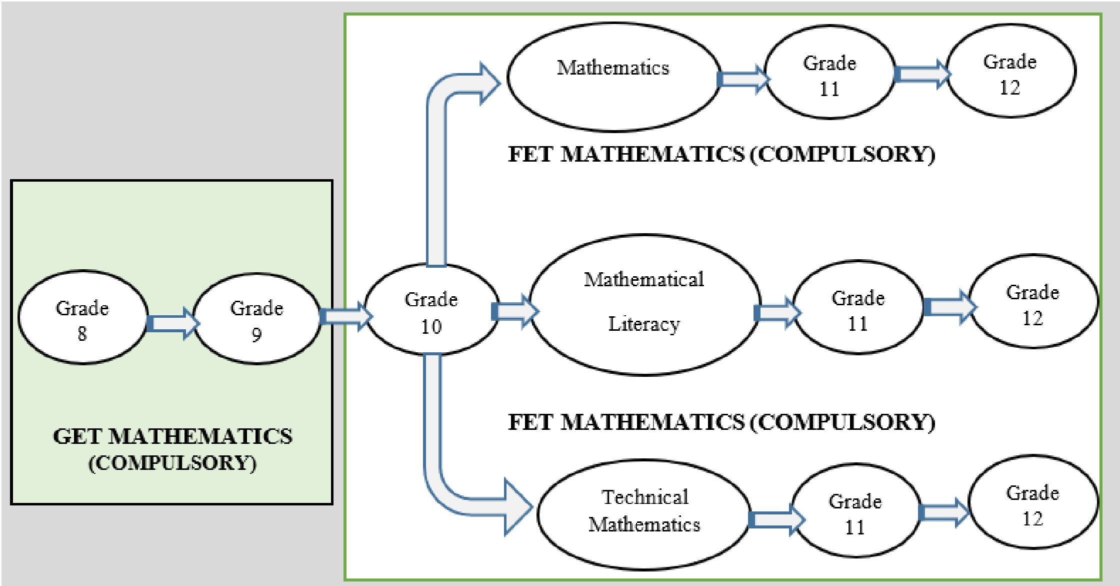

Figure 1. South African secondary school mathematics education system (Source: Author)

analyzed in this research. The structure of the South African and Zimbabwean mathematics education systems, the goals of their secondary school mathematics curriculum, and the topics and content taught at various grade levels are among the variables of interest. There is also a comparison of teaching methods, teaching resources, assessment and grading systems, and mathematics teacher education and training.

Data Collection and Analysis Procedures

READ approach and a priori coding were used to collect and analyze data. READ method is implemented, as follows:

(1) ready your resources ready,

(2) extract data,

(3) analyze data, and

(4) distill your results (Dalglish et al., 2020).

The researchers determined, which documents needed to be studied based on the research goal at the outset. All of the necessary documents (curriculum policy documents, mathematics syllabi, exam papers, and research reports) were freely accessible via online searches. The documents were downloaded and saved in two distinct folders labelled 'South Africa' and 'Zimbabwe' on a computer. Data were extracted from the documents using QDA Miner Lite, a computer-assisted qualitative data analysis software developed by Provalis Research in Canada. Prior to data collection, the researcher knew what type of data will meet the study aim, hence a priori coding was used. Coding is the process of labelling data segments that pertain to the study's purpose with descriptive words, phrases, or category names. A priori codes are those that are generated before data collection utilizing prior knowledge (Stuckey, 2015). The coded data were retrieved from QDA and exported as a single document to another file for future review. The findings of the study are presented and discussed in the section that follows.

Data Trustworthiness

The authenticity of the documents used in this research was ensured by downloading original documents from the two countries' official websites. Authenticity refers to whether the documents are genuine, complete, original, reliable, and unaltered (Kridel, 2017). The downloaded documents were reviewed by the researcher to confirm that the title, author, date of publication, place of publication, and edition were correct. Before being used, documents were also examined for errors and typos. Peer debriefing was used to assess the credibility of the findings (Henry, 2015).

The transferability of findings was enhanced by providing detailed descriptions of the study's setting. Readers are warned not to extrapolate the findings beyond the scope of the study. The audit trail of the study procedures is provided to enhance the dependability and confirmability of the findings (Richards & Hemphill, 2018). Proper in-text citations to information sources were provided to assist readers who may be interested in tracing the sources to confirm the results.

FINDINGS AND DISCUSSION

A general review of South African and Zimbabwean secondary school mathematics education systems

Mathematics is a five-year compulsory subject in South African secondary schools, beginning in grade 8 and ending in grade 12 (**Figure 1**). Learners do the same mathematics in grade 8 and grade 9, known as GET band, and will only have the opportunity to choose one of the three available mathematics streams when they reach grade 10. In grade 8 and grade 9, learners study mathematics with eight other mandatory subjects. Learners in grade 10 may study mathematics, mathematical literacy, or technical mathematics in addition to six other subjects. Mathematics is suggested for learners who select the sciences or commerce streams. A learner cannot take more than one of the three subjects because the subjects are typically taught concurrently in schools and are also assessed concurrently at the end of the year. The mathematics grades 10-12 curriculum aims to "prepare the learners for FET as well as the world of work" (Department of Basic Education, 2011a, p. 8). Learners in the general stream, which covers disciplines like history, consumer studies, and tourism, are encouraged to do mathematical literacy. Depending on their plans for university or college, learners in the commerce stream may also study mathematical

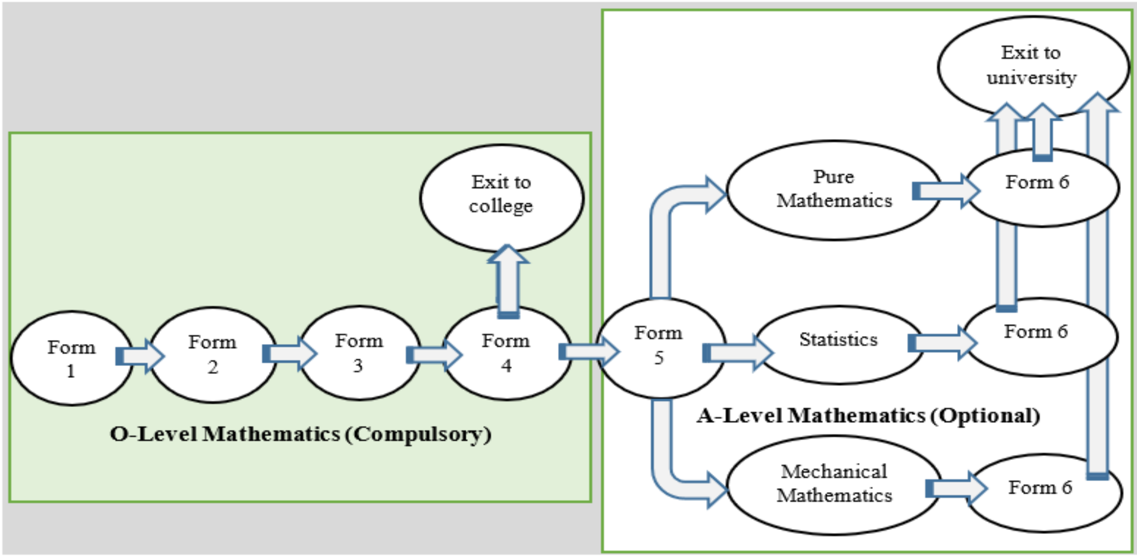

Figure 2. Zimbabwean secondary school mathematics education system (Source: Author)

literacy instead of mathematics. Mathematical literacy, according to Department of Basic Education (2011b, p. 8), seeks to develop competencies that will "allow individuals to make sense of, participate in and contribute to the twenty-first century world." It has great practical applications in real life and people can use it for self-management (Clark, 2012). The policy document for mathematical literacy is silent on whether or not the curriculum prepares learners for postsecondary school education and training. Technical mathematics is recommended for students pursuing technical subjects such as civil technology, electrical technology, mechanical technology, and technical sciences. It provides a direct channel to apprenticeship and meets labor market expectations (Department of Basic Education, 2014). Thus, the Technical mathematics pathway is appropriate for learners who want to pursue technical fields and artisanship at FET colleges. At the time of writing, technical mathematics was exclusively available in South African technical high schools. The South African mathematics education system is depicted in **Figure 1**.

Mathematics is a four-year compulsory course in Zimbabwe for learners planning to leave secondary school at O-level and attend college (**Figure 2**). It is a six-year program for learners planning to graduate from high school at A-level and attend university (**Figure 2**). At O-level, learners study mathematics with seven other subjects. A-level mathematics is optional. At A-level, learners study mathematics alongside two other subjects, depending on their chosen stream. Mathematics can be combined with physics and chemistry (MPC stream), mathematics with biology and chemistry (MBC stream), or mathematics with commercial disciplines like accounting, business studies, or economics. The new competence-based A-level mathematics curriculum offers three options for learners who choose to study mathematics at form 5 and form 6. Learners can choose between pure mathematics, statistics, and mechanical mathematics streams. They are also permitted to pursue more than one of these mathematics streams in order to broaden their degree options at universities (Chikusvura et al., 2021). According to Ministry of Primary and Secondary Education (2015d, p.1), pure mathematics stream is intended for "learners who wish to acquire competences in scientifically and technologically based areas required for the national human capital development needs and enterprising activities in the 21st century." Thus, it prepares learners for university-level studies in science and technology. Statistics stream according to Ministry of Primary and Secondary Education (2015e, p.1) seeks to "develop research and analytical competencies essential for sustainable development and careers such as actuarial science, medicine, education, agriculture, meteorology, and engineering." Mechanical mathematics stream seeks "to provide wider opportunities for learners who desire to undertake technologically and industrially related scientific research areas and careers like architecture and engineering" (Ministry of Primary and Secondary Education, 2015c, p.1).

Figure 1 and **Figure 2** show that the secondary school mathematics education systems in South Africa and Zimbabwe look similar in structure. In upper secondary school, both education systems split into three mathematics streams, providing learners with a variety of options. However, whether or not those streams sufficiently equip learners for postsecondary school education and training remains to be shown. Mathematical literacy stream in South Africa has been extensively criticized for being a watered-down curriculum, with some academics urging that it should be discontinued (Nxumalo, 2015). It does not equip students with the knowledge and skills needed to pursue a variety of career paths (Cranfield, 2012). If you study mathematical literacy, your career options will be significantly limited because many career pathways do not allow mathematical literacy learners to pursue them (South African Institute of Chartered Accountants, 2018). According to reports in Zimbabwe, universities appear to admit students who studied pure mathematics before those who studied statistics and mechanical mathematics (Chikusvura et al., 2021). Thus, both the South African and Zimbabwean secondary school mathematics education systems face issues with alignment with university programs. However, it is unclear whether universities are consulted in the design and development of secondary school mathematics curricula. In Zimbabwe, Ministry of Primary and Secondary Education (2015a) states in the new curriculum framework document that the new education system was developed in consultation with all relevant stakeholders. "[L]earners, parents, teachers, leaders in industry and commerce, farmers, church organizations, civic society, institutions of higher learning, and government ministries and departments" were among those included (Ministry of Primary and Secondary Education (2015a, p. v). This points to the view that universities were consulted

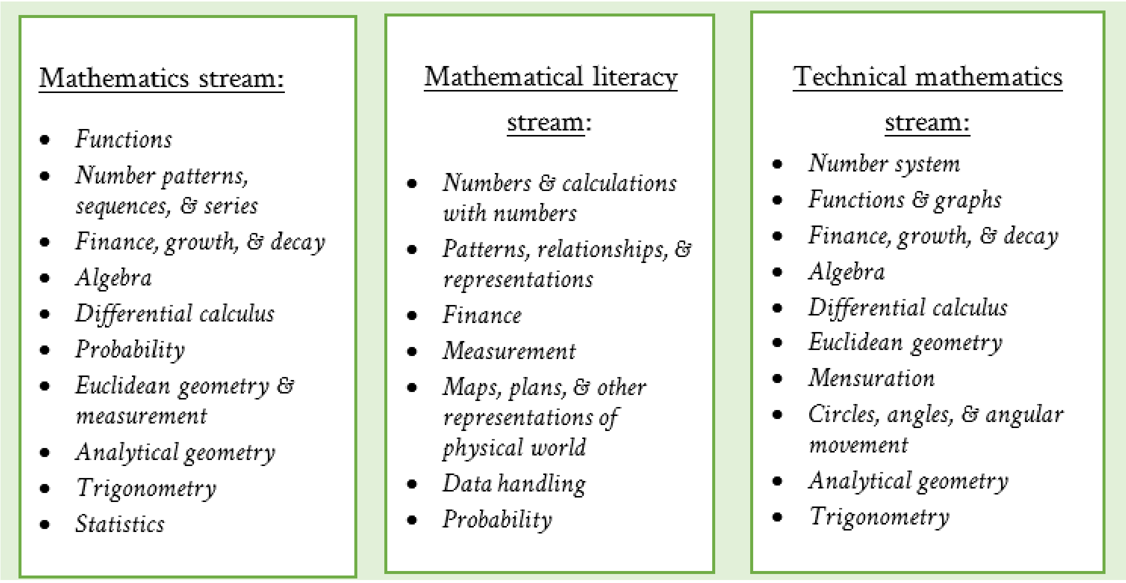

Figure 3. South African secondary school mathematics education system (Department of Basic Education, 2011a, 2011b, 2014)

in developing the new curricula. CAPS documents in South Africa do not specify who contributed to the formulation of the curriculum. It is therefore difficult to establish whether or not universities played a role in aligning the secondary school mathematics curriculum with university requirements. In any event, the preceding analysis shows that universities should be regarded as a crucial stakeholder in the development of secondary school mathematics curricula in both countries. This would help to solve challenges of mismatch between high school mathematics and university needs.

While mathematics is required up to grade 12 in South Africa, it is only compulsory up to form 4 (grade 11) and optional at A-level in Zimbabwe. Zimbabwean secondary school education system permits learners to enter college with only O-level (form 4) mathematics, but their South African counterparts must finish five years of secondary education. There have never been any complaints from Zimbabwean colleges about such learners' lack of mathematics ability. This approach may teach South Africa a valuable lesson. Thus, South Africa may consider releasing learners who want to attend vocational (FET) colleges earlier rather than waiting till they complete grade 12. The South African secondary school mathematics education system, on the other hand, permits learners to choose a mathematics stream of their choice at grade 10, two years sooner than their Zimbabwean counterparts. Zimbabwe might borrow a lesson from South Africa by allowing learners to choose specific mathematics streams in form 3 rather than having a one-size-fits-all mathematics curriculum for all learners up to form 4. Zimbabwe may also explore making mathematics compulsory up to form 6. This is in line with the school of thought, which holds that mathematical thinking is necessary for all citizens to participate in the economy and society (Udale-Smith, 2012). In the following quotation, Vasu (2019, online) expresses the importance of mathematics to all members of society:

> Any person ignorant of mathematics will be at the mercy of others and will be easily cheated. A person from labor class, a businessman, an industrialist, a banker to the highest class of the society utilizes knowledge of mathematics in one form or other. Whoever earns and spends uses mathematics and there cannot be anybody who lives without earning and spending.

At form 5 and form 6 (grade 12 and grade 13), Zimbabwean secondary school learners are required to specialize in only three subjects. This gives them more time to practice their mathematics. In South Africa, grade 12 learners must take mathematics alongside six other subjects, some of which have little relevance to what the learners intend to study at university. This gives South African learners little time to concentrate on mathematics. South Africa might learn from Zimbabwe by enabling learners to specialize in a few subjects so that they have more time to polish their mathematics skills before entering university. This will go a long way toward addressing the problem of learners entering university with weak mathematical skills, which academics at South African universities have extensively noted (Rylands & Coady, 2009; Taylor, 2021).

Secondary School Mathematics Topics and Content in South Africa and Zimbabwe

In South Africa, the curriculum topics covered in the mathematics and technical mathematics streams are nearly identical (**Figure 3**). The sole difference is that in the technical mathematics stream, sequences and series, probability, and statistics have been excluded to accommodate number system, mensuration, circles, angles, and angular movement. Both streams have ten topics each. It might be claimed that the mathematics and technical mathematics streams have similar strengths and are likely to be recognized equally by institutions of higher learning. Another finding is that financial mathematics pervades all areas of mathematics education in South Africa. This is a clear signal that finance is a critical mathematics topic that should not be overlooked in secondary school. The mathematical literacy stream, on the other hand, appears to be weaker because all of its topics represent basic numeracy with no mathematical rigor. It excludes topics such as trigonometry and Euclidean geometry.

In Zimbabwe, pure mathematics, statistics, and mechanical mathematics appear to be distinct disciplines of mathematics with nothing in common except that vectors appear in both the pure mathematics and mechanical mathematics streams. When compared to the statistics and mechanical mathematics streams (**Figure 4**), the pure mathematics stream has fewer topics. All three streams involve some mathematical rigor, and none is greater or weaker than the others.

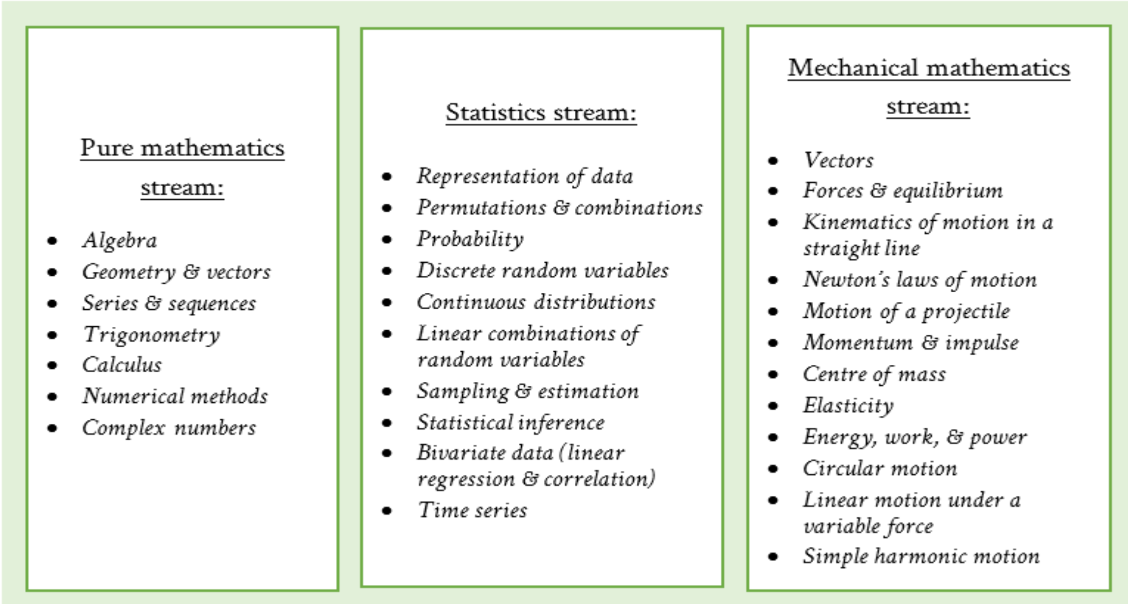

Figure 4. Zimbabwean secondary school mathematics education system (Ministry of Primary and Secondary Education, 2015c, 2015d, 2015e)

In terms of topics and content, there are some similarities and variations between the secondary school mathematics education systems in South Africa and Zimbabwe. Common topics include algebra, sequences and series, coordinate geometry, calculus, trigonometry, probability and statistics. Financial mathematics is not taught in Zimbabwe's secondary school mathematics education system, probably due to the country's high inflation rate and volatile economy, which causes financial figures in textbooks to differ significantly from reality. In Zimbabwe, Euclidean geometry is only taught at O-level (Ministry of Primary and Secondary Education, 2015b) and is not included in the A-level mathematics curriculum. Vectors, numerical methods, and mechanics, on the other hand, are not covered in the secondary school mathematics curriculum in South Africa. The Zimbabwean pure mathematics curriculum appears to be narrower than the South African mathematics stream. However, a closer examination reveals that Zimbabwean pure mathematics curriculum is more comprehensive in algebra, sequences and series, complex numbers, and calculus than South African mathematics curriculum.

In Zimbabwe's secondary school mathematics curriculum, algebra contains direct, inverse, joint and partial variations, partial fractions, identities, modulus functions, matrices, mathematical induction, and groups (Ministry of Primary and Secondary Education, 2015d). These are not included in South Africa's secondary school mathematics curriculum. In Zimbabwe, sequences and series include binomial expansions, Maclaurin and Taylor series (Ministry of Primary and Secondary Education, 2015d). Calculus includes differentiation of trigonometric functions, logarithmic functions, exponentials, composites, implicit and parametric, product and quotient rules, normal to a curve, and first order differential equations (Ministry of Primary and Secondary Education, 2015d). Complex numbers include conjugate, modulus, argument, Argand diagram, polar form, De Moivre's system, and n^{th} roots of unit (Ministry of Primary and Secondary Education, 2015d). All these units are missing from South African secondary school curriculum (Department of Basic Education, 2011a). Complex numbers are studied in the technical mathematics curriculum in South Africa under Number system, but the scope is limited (Department of Basic Education, 2014).

Statistics and probability have a restricted scope in the South African secondary school mathematics curriculum. Statistics includes measures of central tendency and dispersion, data representation using histograms, ogives, frequency polygons, box and whisker diagrams, and scatter plots, as well as linear regression, correlation coefficients, and outliers (Department of Basic Education, 2011a). The probability unit includes mutually exclusive events, complementary events, dependent and independent events, the addition rule, Venn diagrams, tree diagrams, contingency tables, and the fundamental counting principle (Department of Basic Education, 2011a). Because statistics (and probability) is a separate stream in Zimbabwe, it has a considerably broader and more in-depth focus (**Figure 4**). South Africa, on the other hand, has a stronger and more important geometry component known as Euclidean geometry, which is absent from the Zimbabwean A-level mathematics program. Zimbabwe can improve its pure mathematics education by incorporating Euclidean geometry within the A-level mathematics curriculum, which is valued in many countries. South Africa, on the other hand, may explore reducing either the number of topics in the mathematics stream or the number of subjects learners do at grade 11 and grade 12 (Gerassi, 2021). This would allow them to raise the depth of the remaining topics in order to provide learners with a solid mathematics foundation for university studies. The mathematical literacy stream, which is widely criticized by South African university researchers, might be replaced by a more comprehensive stream that integrates probability and statistics.

Suggested Time Allocation

The mathematics curriculum in South African secondary schools allots 4.5 hours of teaching time each week for mathematics, mathematical literacy, and technical mathematics (Department of Basic Education, 2011a, 2011b, 2014). Pure mathematics and statistics each receive five hours 50 minutes per week in Zimbabwe, with mechanical mathematics receiving the most time (six hours 40 minutes per week) (Ministry of Primary and Secondary Education, 2015c, 2015d, 2015e). Thus, Zimbabwean secondary school mathematics education system devotes more time to mathematics teaching than the South African secondary school mathematics education system. The rising emphasis on teaching for understanding and presenting learners with a variety of problem-solving strategies necessitates extra time, particularly when presenting new topics, to guarantee a fundamental understanding before progressing to more complex concepts (Prendergast & O'Meara, 2017). After teaching mathematics in South African secondary schools from 2008 to 2021, the author can unequivocally assert that 4.5 hours per week is insufficient. Many South African mathematics teachers are expected to teach before lessons, after school hours, and on weekends, to comprehensively cover the curriculum and address learning gaps. This is due to the limited time allocated to mathematics in the school timetable. South Africa may explore increasing the amount of time spent on mathematics in upper secondary education. Similar appeals have been made elsewhere (Prendergast & O'Meara, 2017).

Suggested Teaching Approaches and Resources

The South African secondary school mathematics curriculum policy documents for grades 10-12 make no recommendations for teaching approaches and resources to be used by mathematics teachers in various topics. Individual mathematics teachers must determine what methods and resources to employ in their lesson presentations. New concepts (particularly Euclidean geometry and probability) were added in the South African CAPS for mathematics grades 10-12, which some teachers had never encountered before. It may be beneficial to provide teachers with suggestions on possible instructional approaches to utilize in these topics. Thus, South Africa may consider revising its curriculum documents to include proposed teaching methodologies for particular topics and concepts. South Africa, however, is well renowned for investing more money and resources in its education system than the majority of African countries. It devotes a greater amount of its budget to education than the USA, the UK, and Germany (Cohen, 2017). After 13 years of teaching mathematics in South African secondary schools (2008-2021), the author can say that the South African Department of Basic Education does its best to provide learners and teachers with the resources they need to learn and teach mathematics. Mathematics teachers' guides and mathematics learners' textbooks from various publishers are distributed to teachers and learners at the start of the school year. Textbooks are periodically updated to reflect the current curriculum. Notebooks, exercise books, calculators, pens, pencils, and mathematical sets are offered to learners. Mathematics textbooks are rarely shared. Teachers are given additional teaching resources by curriculum advisors to utilize in their mathematics lessons, such as past exam papers, videos, and Power Point presentations.

To support the use of ICT in the teaching and learning of mathematics, most secondary schools have access to electricity, internet connectivity, computer labs, and overhead projectors.

A constructivist-based teaching and learning approach is recommended for form 5 and form 6 learners in Zimbabwean secondary school pure mathematics curriculum. This is intended to develop learners' capacity to create new mathematical knowledge based on prior learning and to encourage creativity and originality (Ministry of Primary and Secondary Education, 2015d). It will also promote the free exchange of ideas and information, inclusivity and respect for one another's points of view, collaboration and cooperation, intellectual honesty, diligence, and perseverance (Ministry of Primary and Secondary Education, 2015d). To promote this, methods such as guided discovery, group work, interactive e-learning, problem solving, discussion, and modeling should be used (Ministry of Primary and Secondary Education, 2015d). The mechanical mathematics curriculum promotes the use of learner-centered, multi-sensory approaches that are practical in nature (Ministry of Primary and Secondary Education, 2015c). Problem solving, modelling, group work, guided discovery, demonstration and illustration, experimentation, interactive e-learning, self-activity and independent learning, exposition, visual tactile, research, and expert guest presentation are all suggested ways for teaching mechanical mathematics (Ministry of Primary and Secondary Education, 2015c). The statistics curriculum places a strong emphasis on learner-centeredness, engagement, and inclusion (Ministry of Primary and Secondary Education, 2015e). Demonstrations, experimentation, group work, question and answer, problem solving, discussion, research and presentations, project-based learning, simulation and modeling, field work, and games are among the suggested teaching and learning approaches in statistics (Ministry of Primary and Secondary Education, 2015e). All three mathematics streams recommend ICT tools, talking books or software, relevant texts, geometrical instruments, and a geoboard as instructional resources (Ministry of Primary and Secondary Education, 2015c, 2015d, 2015e).

Zimbabwean secondary school mathematics curriculum policy documents appear to be comprehensive on paper. However, providing adequate methodology and guidance to teachers, the implementation of the newly designed competence-based mathematics curriculum has been hampered by a severe lack of the necessary resources. Zimbabwean mathematics teachers who participated in a recent study by Chikusvura et al. (2021) complained about a shortage of fundamental resources such as mathematics textbooks for both teachers and learners. Schools rely on parents to purchase mathematics textbooks, tablets, and laptops for their children in order for them to learn mathematics effectively (Chikusvura et al., 2021). Given the country's economic situation, few parents are able to get all of the essential resources for their children, and learners and teachers are compelled to share the little resources available. In certain schools, ten or more learners are said to share a single textbook (Masiyiwa, 2018). This is definitely a deplorable condition that Ministry of Primary and Secondary Education in Zimbabwe must address immediately. Most rural secondary schools lack electricity and computer labs. This makes the use of ICT tools and approaches such as experimentation, simulation, and interactive e-learning a pipe dream for the vast majority of rural schoolchildren and teachers. The following quotation accurately describes the situation in Zimbabwe:

> While some schools do have computer labs, there is no electricity to render computer benefits. Schools with electricity only receive it during the hours where the school is not in session. Even schools in urban areas complained of power outage and internet connectivity issues. Students, teachers, and parents thus are unable to access educational information for developing skills and competencies. Without these resources, the outcomes and results of the ZCF (Zimbabwe curriculum framework) will be difficult to realize (Gory et al., 2021, p. 164).

In light of this, the achievement of the new Zimbabwean secondary school mathematics curriculum's specified goals is compromised by a lack of resources. Zimbabwe should take a lesson from South Africa in terms of allocating resources to mathematics and science education.

Table 1. Weighting of content areas (adapted from Department of Basic Education, 2011a, p. 55)

	Grade 10	Grade 11	Grade 12
Paper 1			
Algebra & equations (& inequalities)	30±3	45±3	25±3
Patterns & sequences	15±3	25±3	25±3
Finance & growth	10±3		
Finance, growth, & decay		15±3	15±3
Functions & graphs	30±3	45±3	35±3
Differential calculus	-	-	35±3
Probability	15±3	20±3	15±3
Total	**100**	**150**	**150**
Paper 2			
Statistics	15±3	20±3	20±3
Analytical geometry	15±3	30±3	40±3
Trigonometry	40±3	50±3	40±3
Euclidean geometry & measurement	30±3	50±3	50±3
Total	**100**	**150**	**150**

Table 2. Codes & percentages for recording & reporting learners' performance (Department of Basic Education, 2011a, p. 56)

Rating code	Description of competence	Percentage
7	Outstanding achievement	80-100
6	Meritorious achievement	70-79
5	Substantial achievement	60-69
4	Adequate achievement	50-59
3	Moderate achievement	40-49
2	Elementary achievement	30-39
1	Not achieved	0-29

Assessment, Weighting, and Grading System

South Africa

Learner assessment in grades 10-12 across all three mathematics streams in South Africa consists of school-based assessment (SBA), also known as continuous assessment (CASS), and end-of-year examination. School-based assessment contributes 25% to the final promotion mark, and end-of-year examination contributes 75% to the final promotion mark (Department of Basic Education, 2011a, 2011b, 2014). For their school-based assessment, students are expected to complete seven formal assessment tasks (Department of Basic Education, 2011a, 2011b, 2014). All assessments in Grades 10 and 11 are set internally, however in grade 12, CASS is set and marked internally but externally moderated, and the final examination is set, marked, and moderated externally (Department of Basic Education, 2011a, 2011b, 2014). In grade 10 and grade 11, the mid-year examination and the project are given more weight, whereas in grade 12, the preliminary examination and the project are given more weight. Grade 10 and grade 11 learners are not provided with a formula sheet when writing tests and examinations (Department of Basic Education, 2011a, 2011b, 2014). The trial exam is only given in grade 12 to determine learners' readiness for the final exam.

The final examination in all three mathematics streams consists of two examinations, paper 1 and paper 2. Grade 10 papers are set out of 100, with each paper lasting two hours (Department of Basic Education, 2011a, 2011b, 2014). Grade 11 and grade 12 examination papers are set out of 150, with each paper lasting three hours (Department of Basic Education, 2011a, 2011b, 2014). The weighting of content areas in examination papers at each grade level in upper secondary school is specified in the mathematics curriculum policy guidelines. **Table 1** shows that in grade 10 and grade 11, greater emphasis is placed on trigonometry, Euclidean geometry, functions and graphs, and algebra and equations. In grade 12, more emphasis is placed on functions and graphs, differential calculus, analytical geometry, trigonometry, and Euclidean geometry.

Table 3. Continuous assessment tasks for ordinary level mathematics (adapted from Ministry of Primary and Secondary Education, 2015b)

Level	Assessment tasks	Frequency	Weighting
Form 1	Topic tasks	1 per term	4.5%
	Written tests	2 per term	
	End of term tests	1 per term	
Form 2	Topic tasks	1 per term	4.5%
	Written tests	2 per term	
	End of term tests	1 per term	
Form 3	Topic tasks	1 per term	4.5%
	Written tests	2 per term	
	End of term tests	1 per term	
Form 4	Topic tasks	1 per term	4.5%
	Written tests	2 per term	
	End of term tests	1 per term	
Form 1-4	Project	2	12%
Total			**30%**

The final promotion mark will then be rated using a scale that ranges from 1 (fail) to 7 (pass with distinction). **Table 2** displays the grading scheme used in South Africa to report learner performance across all subject areas.

A learner who receives 30% in mathematics, mathematical literacy, or technical mathematics is regarded to have passed at the elementary level, according to the grading system in **Table 2**. Several advocacy groups have criticized South Africa's grading system for recognizing 30% as a pass mark in mathematics. For example, One South Africa, led by Mmusi Maimane, filed a petition urging the education minister to raise the pass mark for all subjects to 50%. The organization argued that accepting 30% sets low standards for South African teachers and learners and will harm the country's education system and economy (Vermeulen, 2022).

Zimbabwe

In Zimbabwean secondary schools, learner assessment in mathematics is made up of 30% continuous assessment and 70% examination (Ministry of Primary and Secondary Education, 2015b, 2015c, 2015d, 2015e). The curriculum policy documents state that assessment should cater for all learners. To this end, "[a]rrangements, accommodations, and modifications must be visible in both continuous and summative assessments to enable candidates with special needs to access assessments and receive accurate performance measurement of their abilities" (Ministry of Primary and Secondary Education, 2015b, p. 70, 2015c, p. 18, 2015d, p. 29, 2015e, p. 23). At O-level, the 30% is spread out over four years, beginning with form 1 and ending with form 4 (**Table 3**). Similarly, the 30% at A-level is spread across two years, beginning in form 5 and ending in form 6 (**Table 4**). Topic tasks, written tests, end-of-term tests, and projects are among the activities that contribute 30% to continuous assessment. At O-level, the project is given greater weight than the other tasks, whereas at A-level, it is given equal weight in pure mathematics and mechanical mathematics.

The final examination at O-level mathematics consists of two equally weighted papers set out of 100 marks and the duration of each exam is 2.5 hours (Ministry of Primary and Secondary Education,

Table 4. Continuous assessment tasks for advanced level mathematics (Ministry of Primary and Secondary Education, 2015c, 2015d)

	Term	NTT	NWT	NETT	Project	Total
Form 5	2	1	2	1	1	
	3	1	2	1		
Form 6	4	1	2	1		
	5	1	2	1		
Weighting		25%	25%	25%	25%	100%
Actual weight		7.5%	7.5%	7.5%	7.5%	30%

Note. NTT: Number of topic tasks; NWT: Number of written tests; & NETT: Number of ends of term tests

2015b). Paper 1 is made up of short, structured questions covering all syllabus topics, and all questions are required (Ministry of Primary and Secondary Education, 2015b). The second paper is broken into two portions. Section A has five mandatory questions, and section B requires learners to answer four questions from a list of seven possibilities (Ministry of Primary and Secondary Education, 2015b).

The final examination at A-level consists of two 3-hour papers. Pure mathematics papers are assessed out of 120 marks (Ministry of Primary and Secondary Education, 2015d). Paper 1 is made up of mandatory questions, whereas paper 2 is broken into two sections: section A and section B. Section A is compulsory, and in section B, learners must select five of the seven available options. The statistics examination follows the same format (Ministry of Primary and Secondary Education, 2015e). Mechanical mathematics papers are set out of 100, with paper 1 consisting of mandatory questions and paper 2 allowing learners to choose any five of the eight available options (Ministry of Primary and Secondary Education, 2015e).

Zimbabwe tracks and reports on student performance using a grading system. Grading is the process of converting numerical examination marks for candidates into alpha grades. A, B, C, D, E, and U are the grades used to report candidates' examination achievement at O-level examinations. Grade A in O-level translates to very good and is worth five points, B is good and is worth four points, C is average and is worth three points, D is weak and is worth two points, E is extremely bad and is worth one point, and U is ungraded. A passing grade at this level is a C or better. A, B, C, D, E, O, and F are A-level examination grades. A is extremely good, C is average, E is pass, O indicates failure at A-level but the attainment of at least grade C at O-level, and F is failed. The point system is then applied to grades A through E, with five points assigned to the highest grade, A, and 1 point awarded to the lowest grade, E. To be eligible for university studies in Zimbabwe, students must have completed at least five O-Level subjects, including English language, with a grade C or higher. In addition, they must have passed at least two A-level subjects with a grade C or higher that are relevant to the desired program of study. **Table 5** shows the Zimbabwean secondary school grading system at O-level and A-level.

Similarities and differences in assessment, weighting, & grading systems

Continuous assessment is part of the ultimate promotion mark that learners will receive at the end of their secondary school course in both South Africa and Zimbabwe. CASS is, however, 5% greater in Zimbabwe (30%) than in South Africa (25%). Furthermore, unlike in South Africa, CASS in Zimbabwe is carried out across several years rather than finished in a single year. Learners' work in forms 1-4 contributes to their continuous assessment mark at O-level. Similarly, form 5 learners' work contributes to their final CASS mark at A-level.

Table 5. Grading system at ordinary &d advanced level (Mhute, 2019)

O-level			A-level		
Grades	Percentage	Points	Grades	Percentage	Points
A	80-100	5	A	80-100	5
B	60-79	4	B	60-79	4
C	50-59	3	C	50-59	3
D	40-49	2	D	40-49	2
E	30-39	1	E	30-39	1
U	0-29	0	O, F	0-29	0

This is a beneficial practice since it encourages learners of all grade levels to take their schoolwork seriously.

In Zimbabwe, a pass mark in mathematics begins at 50%, whereas in South Africa, even 30% is considered a pass. To align with international standards, South Africa may consider raising its pass mark to 50%. Before sitting for the final examination, grade 12 students in South Africa take a trial exam to assess their preparation. This is a good practice that Zimbabwe can follow. In the final year of secondary school, both countries administer two mathematics papers, paper 1 and paper 2. However, they differ in terms of mark distribution and question paper structure. In the South African mathematics education system, both papers are assigned 150 marks and all questions are mandatory. In the Zimbabwean mathematics education system, both papers are assigned 120 marks and only paper 1 has mandatory questions. Paper 2, section B allows Zimbabwean secondary school mathematics candidates to choose five questions from several options. South Africa may also relax its mathematics assessment system by enabling learners to choose, which questions to answer in paper 2 rather than having a rigorous question paper with all questions mandatory. This may be more beneficial to learners' interests than a rigid structure.

Zimbabwe gives learners greater exam time (three hours for 120 marks) than South Africa (three hours for 150 marks). Singapore, which is recognized as one of the finest countries in mathematics education based on TIMSS and PISA results, devotes three hours to a 100-marks question paper (Singapore Examinations and Assessment Board, 2020). As a result, there is no basis for countries that rank among the worst in international comparative studies to provide students less exam time than top achievers. We are simply disadvantageous to our students for spurious reasons.

The topic weighting for paper 1 and paper 2 of the final examinations is outlined in the mathematics curriculum documents for secondary schools in South Africa. This is really beneficial since it allows mathematics teachers to identify areas where they should focus their efforts because those topics have a bigger impact than others. Zimbabwe can learn from South Africa in terms of determining how the final exam marks will be distributed among the several topics.

Mathematics Teacher Training and Professional Development

Because teachers' colleges are no longer in existence, universities provide mathematics teacher education in South Africa. This has resulted in a severe shortage of mathematics teachers in secondary schools, as the number of teachers leaving the system does not equal the number of graduates from universities each year. Furthermore, South African learners who achieve high grades in mathematics in grade 12 appear to pursue non-teaching degrees in the sciences. In Zimbabwe, on the other hand, both colleges and universities train mathematics teachers, which helps to alleviate teacher shortages. Mathematics teachers in forms 1-4 are trained at secondary teacher colleges, but mathematics teachers in form 5 and form 6 are trained at universities. In order to redress historical inequalities and conform to international norms, both South Africa and Zimbabwe have revised their secondary school mathematics curricula. Mathematics curriculum changes, on the other hand, necessitate continual in-service training for mathematics teachers in order to equip them to handle the new curriculum.

The introduction of CAPS has presented severe hurdles to in-service mathematics teachers due to new topics that necessitate new teaching methodologies. After witnessing and experiencing the implementation of CAPS in South Africa, the author can say that the training obtained by mathematics teachers was insufficient, with trainers focusing more on content than approach. The establishment of the competence-based mathematics curriculum in Zimbabwe has also been fraught with difficulties. Gory et al. (2021) discovered that in-service training for teachers in Zimbabwe on the new curriculum mostly focused on syllabus interpretation rather than teaching methods. Furthermore, "this was a one-time annual training rather than ongoing training support" (Gory et al., 2021, p. 165). Mathematics teachers continue to receive regular help from mathematics curriculum consultants in South Africa, which is a good practice that Zimbabwe should replicate. In Zimbabwe, those tasked with overseeing the implementation of the new competence-based curriculum have been accused of lacking sufficient understanding to assist mathematics teachers (Chikusvura et al., 2021).

After working as a mathematics teacher in both countries, the author discovered that most mathematics teachers in South Africa and Zimbabwe lack the drive to develop themselves through personal study and qualification upgrades. This is because both the South African and Zimbabwean governments pay teachers with higher qualifications the same remuneration as those with lower qualifications. As a result, there is little motivation for teachers to advance their education to the master's or doctoral degree level. Instead of being lifelong learners, the teachers wait for curriculum advisors to direct them. In Finland, every secondary school mathematics teacher is required to hold a master's degree, and as a result, Finland has one of the world's best mathematics education systems.

RECOMMENDATIONS AND CONCLUSION

Based on the study's findings, the author suggests that South Africa and Zimbabwe can learn from each other's secondary school mathematics education systems. South Africa may increase exam duration and pass mark, and spread CASS over a longer period of time. They may also reduce the number of subjects taken at the grade 11 and grade 12 levels to give learners more time to study mathematics. Redesigning question papers to provide learners optional questions may also improve secondary school mathematics education in South Africa. Zimbabwe, on the other hand, can improve its secondary school mathematics education system by allocating more resources to mathematics education. In addition, they should consider making mathematics compulsory for all A-level candidates, conducting trial examinations, and appointing mathematics curriculum advisors to provide regular support to mathematics teachers in schools. Both countries should give incentives to encourage mathematics teachers to keep learning and upgrade their credentials as part of their personal growth and in accordance with the practice of lifelong learning. Finally, countries should understand that no curriculum is flawless, and hence curriculum development, review, and implementation should be continual processes.

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