



Viability Problem-Solving Approach in Teaching Mathematics at This Era: Retrospection of the Six Decades of Mathematics Education in Ghana

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Abstract: This paper attempts to preview the viability of the problem-solving approach in teaching mathematics in Ghana in this digital age. The historical development of mathematics Education in Ghana since the nation's independence from British rule in 1957; and how these have influenced current practice in teaching mathematics and beyond, detailing the reliance on traditional instructional strategies such as lectures and quizzes and how reformed instructional practices where students have the opportunity to link mathematical concepts to real-life situations (problem-solving and inquiry-based learning) have been provided. Some recommendations such as enrolling back in the TIMSS Assessment as it embraces the modern pedagogies in mathematics problem-solving in order to train the young ones to be innovative, creative, critical thinkers and problem solvers, opting for other mechanisms of assessment with international repute that can help transform the country's school mathematics than the continuous reliance on WAEC as the monopolist examination body and the intensification of continuous professional teacher development to ensure that the serving teachers are abreast with modern best practices have been made to improve students' performance in the subject as a means of adopting modern pedagogical skills in delivering mathematics education in Ghana.

Keywords: Problem-Solving Approach, Retrospection, Realistic Mathematics Education (RME), Problematize

1. Introduction

According to its originator George Polya, problem-solving has no single definition due to its connection with real-life situations [1]. Real-life situations differ in many forms, and the approach to finding solutions to contextual problems also differs. The real-life conditions are faced with many challenges that need innovative solutions. The very survival of humans on this earth is endangered by an array of problems ranging from unemployment to pandemics, supply chain to waste management, climate change to natural disasters, advanced technology to cyber and security issues,

and what have you [2–4]. All these mishaps need individuals who are innovative, creative, critical thinkers, and versatile in problem-solving to put the condition under check.

Practically, these are the values that the problem-solving approach in learning mathematics seeks to imbibe in the students so that they become independent in their thinking and resolute in handling any challenges that arise or may occur in daily life activities [5–7]. In a problem-solving method, the students learn by working on contextual problems. This enables them to learn new knowledge by facing the problems to be solved. The student is expected to go through three stages; analyze the problem; solve the problem and authenticate the solution [8, 9]. These values

help the student observe, understand, deduce, find solutions and relate the solution to real-life situations, which leads to a holistic conceptual understanding [10].

As indicated by A. Wijaya, M. van den Heuvel-Panhuizen, and M. Doorman [11], the problem-solving approach is the most critical principle of mathematics reform, allowing students to problematize mathematics. This allows students to wonder why things are, inquire, search for solutions, and resolve incongruities. It suggests that the curriculum and instruction should start with students' problems, dilemmas, and questions [12]. As observed by [13], problem-solving in mathematics education allows students to search for patterns and relationships, analyze patterns and identify which methods work and which do not. The student is constantly engaged in justifying results, evaluating and challenging the thought of others, suggesting that he/she is necessarily and optimally engaging in reflective thinking about the ideas involved in finding the solution to contextual problems.

2. The Position of the Problem-Solving Approach in Mathematics Education Across the Globe

Problem-solving has been the focus of school mathematics for decades and goes beyond finding answers to word problems and exercises labeled "problem-solving." Problem-solving standard says that all students should build new mathematical knowledge through problem-solving [14]. Unfortunately, Problem Solving in mathematics has often been overlooked in the past in favor of activities towards mechanical or computational skills [8, 14].

In 1968, a new approach was introduced in the Netherlands, spearheaded by Hans Freudenthal, known as the Realistic Mathematics Education (RME) [15]. RME is a domain-specific instruction theory for mathematics, prioritizing rich and realistic situations in the learning process. It is the source of initiating the development of mathematical tools, concepts, and procedures in a context that offers students the opportunity to apply them in their daily activities [16]. RME has now evolved into the primary approach to mathematics education in the Netherlands and has now gained recognition in the mathematics curriculums in other countries worldwide [17–19].

The birth of the RME was in response to the need for radical changes and improvements in the teaching and learning mathematics in western countries [15, 20]. This was due to the realization of the increasing importance of mathematics and its applications for society and the availability of new insights into teaching and learning mathematics. RME, over the years, has become the national policy for teaching mathematics at both the primary and secondary levels in the Netherlands. The policy has gone through several reviews and is still under review. The ministry of education has tasked a team of experts to rethink and revise the current curriculum further to enhance students' future personal and professional life. Interestingly, the

review's focus was to emphasize the importance of starting primary education with mathematical problem solving and reasoning.

The realistic mathematics education policy, which has been a significant boost for the problem-solving approach, has become a household name in the field of mathematics education across the Globe. Most of the best-performing countries in the TIMSS assessment project have reviewed their mathematics curriculum to absorb the RME. The TIMSS Reports have demonstrated that Countries like the United States, United Kingdom, China, Indonesia, and the likes have adopted the RME for over two decades now, and they are making gains in terms of performance in mathematics in international Assessments [21].

3. Benefits of Problem-Solving Approach to Mathematics Education

Schifter and Fosnot (1993), as cited in [22], assert that if the creation of the conceptual networks that constitute each individual's map of reality, including their mathematical understanding, is the product of constructive and interpretive activity, then it follows that no matter how lucidly and patiently teachers explain to their students, they cannot understand for their students.

Arguably, equipping students to work on contextual problems in Mathematics make them flexible and creative. Students construct their knowledge; not just students, but all people, all of the time, construct or give meaning to things they perceive or think about. Students are continually coming up with ways of tackling and solving problems that their educators or teachers may not have thought of before or even know of. It provides an opportunity for students to explore ideas and so gives them the chance to extend their creativity in the classroom. The exciting thing about problem-solving is that it is not only the brilliant students who are always the ones coming out with creative ideas; the weaker ones contribute their quota. Because children seem to enjoy almost every part of problem-solving and get quite involved with them, it helps them to gain a positive attitude towards the subject [11].

Students' insecurity that they experience towards problem-solving may be because they have never met open-ended problems before. Many mathematics teachers have traditionally provided students with only algorithms to practice and copy the algorithm. This is not surprising that many students feel insecure in more open-ended problem-solving situations. However, if teachers carefully introduce and handle concepts gradually, students will be able to overcome their initial insecurities [23].

Furthermore, advocating problem-solving in mathematics classrooms can in no way be deemed as wasting of time since it would instead train students to become junior research mathematicians. The way students tackle problems is the same way a research mathematician tackles research problems. There is very little difference between students'

using the Scientific Approach to solve a problem and mathematicians using it to do research. Hence through problem-solving, students get a much better feel of what mathematics is about than they get in the more traditional type of teaching.

Inadvertently, traditional mathematics is always being taught to individuals working on their own; therefore, encouraging problem solving among the students would inculcate their cooperative learning skills. Very little encouragement is being given to cooperative learning in the traditional approach to teaching mathematics but only focuses on developing computational skills. One of the expected learning objectives of the Junior High School mathematics curriculum introduced in Ghana in the 1980s was to encourage students to work cooperatively with other students in carrying out activities and projects in mathematics [24]. Mathematics problem solving allows the learners to carry out practical and investigational works and undertake extended work to explore more and find solutions to non-routine problems. It is believed that students working cooperatively with each other will help develop an interest in mathematics and mathematical communication skills that will sharpen their problem-solving strategies. Studies have proven that promoting language activities in mathematics lessons through discussion appears to increase learners' enjoyment and thereby help them to think and reason mathematically.

It is evident from the above discussion that problem-solving plays a pivotal role in the development of mathematics in any nation. Hence, it helps to develop critical thinking in the learners' minds. One of the scopes of the senior high school curriculum in Ghana is to teach problem-solving and its application in mathematics. Even though problem-solving and its application have not been made a topic by itself in the syllabus, nearly all topics include solving word problems as activities. According to the senior high school curriculum developers, it is their hope that teachers and textbook developers will incorporate appropriate problems that will require Mathematical thinking rather than mere recall and use of standard algorithms [25].

4. Mathematics Education During Gold Coast Era

Gyang (1980), cited in [26], observed that Ghana's mathematics curriculum at the elementary school level before independence from British rule in 1957 was arithmetic. The traditional school arithmetic taught primarily involved mechanical number facts and tables of measurements. Some of the books used then were 'Simon and Milliken's Arithmetic' and the 'Larcombe's Arithmetic series. The focus of mathematics was; the four rules and regulations; domestic arithmetic; and literal arithmetic (i.e., use of formulae). One remarkable feature of the series was its accompanying speed test in mental arithmetic. Larcombe's Graded Speed Tests in Mental Arithmetic were developed for pupils aged 9 to 14

years and were to be administered at the average rate of a minute per sum. These graded tests aimed to foster greater rapidity and accuracy in dealing with numbers and sums. At the secondary school and the teacher training school levels, mathematics was in three main branches: arithmetic, algebra, and geometry. They were taught largely using British grammar school textbooks such as 'School Arithmetic' and 'School Algebra' by Channon and Smith (1938, 1948); and 'School Geometry' by Durell (1939) [24].

5. Revolution and Innovative Changes in School Mathematics at Ghana's Independence

Global mathematics education during the 1960s took a dramatic turn for several reasons. Prominent among them was the discovery of more mathematics than ever existed in the history of humanity. Several new results were reached in mathematics and announced. New methods and techniques for solving old and new problems were developed, and new concepts were created [26]. These developments led to a careful formulation of ideas and a greater precision of mathematical language. Sets, and to a lesser extent, functions, emerged as unifying concepts [27]. The development of the ideas of sets and the view that young children could learn much more than educators had previously thought possible advocated by leading psychologists like Jerome Bruner led to the acceptance of Suppes' (1963) premise that "all mathematics can be developed from the concept of set and operation upon set."

Again, mathematics' significant role in World War II in terms of technology also gave mathematics the needed attention. There was, therefore, the need to search for more pedagogical approaches to enhance the teaching and learning of mathematics to create more technologists.

The calls by the United States' University Mathematicians for a paradigm shift in content and pedagogy in the school mathematics curriculum was another factor. The calls were fuelled by the abysmal performance put up by their students, which they were dissatisfied with.

6. School Mathematics in Ghana After Independence

As documented by UNESCO (1961) cited in [26], there was a conference of ministers of education in Africa to revitalize and restructure the inherited colonial curriculum to suit the African soil. This led to the inauguration of the Africa Mathematics Program (AMP). The AMP managed to blend experience from Africa, America, and Britain to produce mathematics books to enhance smooth and better mathematics education in Africa, especially the English-speaking countries. The first mathematics series that was produced was the Entebbe Math Series. The Entebbe Math Series was later developed into the Joint School Project (JSP)

for secondary schools.

In order to get mathematics that was more Ghanaian, a couple of local publishers were tasked to produce local mathematics books. These were the New Mathematics for Primary Schools (NMPS), Modern Mathematics for Elementary Schools, Book 1 to Book 8, West African School Mathematics, usually referred to as AWAM; for Middle Forms 3 and 4 (Gibson and Mar dell, 1965). The projects were funded by three UK agencies - The Nuffield Foundation, the Centre for Educational Development Overseas, and Overseas Development Administration, all in London. Locally the Mathematical Association of Ghana (MAG), the University of Ghana, and the Ministry of Education Ghana provided support. The AMP was later developed into West African Regional Mathematics Programmes (WARMP) for the three participating countries in West Africa, namely, Ghana, Liberia, and Sierra Leone. The Ghana Mathematics Series (GMS) textbooks and Teacher's Handbooks, which were used in the country for three decades, were products of the WARMP [26] hinted.

7. Methods for Teaching School Mathematics in Ghana

Until recently, the cane was an excellent negative motivational technique in teaching mathematics. As observed by [26], the cane was used excessively to make pupils know the tables of numbers and measurements and to solve problems of a practical nature in measuring, commerce, and so on. The teachers' method was to force pupils to use repetitive and rote learning techniques. However, this method, as observed by Gyang (1979) cited in [28], many of the pupils did not like mathematics and developed genuine hatred for it. The paper noted that school mathematics was characterized by punishment, force, and fear. (Gyang, 1979: 23), as cited in [26], recounts how fear of mathematics led many pupils to end their schooling prematurely. According to [26], the traditional method of teaching school mathematics at both the Primary and Junior Secondary Schools emphasized basic skills, predominantly computational, until the late 1980s.

The 1987 Educational Reform saw the introduction of Modern Mathematics, which was developed with a renewed mindset to make mathematics teaching and learning meaningful and less computational. However, Mereku (1995) cited in [29] found that the pupils' achievement in mathematics in Ghana was still meager, notwithstanding the introduction of new content and new modern approaches and skills for teaching by the Ghana Mathematics Series. The paper observed that although there was much hope in the reform because of the inclusion of new knowledge and skills, the learning/teaching activities that could encourage the use of such teaching skills were not incorporated. Therefore, the teachers themselves were not aware of how to teach the

topics in Modern Mathematics, hence the poor performance of the pupils.

It is sad to note that several reforms took place to restructure the content and methods of instruction to suit modern trends, but much did not change in terms of pedagogy. It was, therefore, not surprising when [30] observed that Ghanaian students who took part in the TIMSS could only answer questions that demanded computational skills and hence could not perform well. Ghana's continuous abysmal performance in the TIMSS pulled them out after the second attempt in 2007 and has still not enrolled back. However, recent studies by [31] indicate that some students who like mathematics attribute their interest in learning mathematics to their teachers' instructional practices that provide opportunities for them to explain their mathematics ideas. A further peruse of the analysis indicates that the grade 8 students who perform well in TIMSS were taught by teachers who seem to employ both traditional instructional strategies such as lectures and quizzes and reform instructional practices where students have the opportunity to link mathematical concepts to real-life situations [31, 32].

The analysis conducted by [33], shows that the trends in performance of Senior High students in Ghana in the WASSCE, observed that poor teaching methods had been a contributory factor responsible for student failure. It is clear that most of the mathematics teachers in Ghana today still do not see the urgency to switch to innovative teaching approaches like problem-solving and inquiry-based learning. However, it remains with the development of computational skills.

8. The Use of Modern Strategies in Teaching School Mathematics in Ghana

As part of measures to improve teacher quality, the Government of Ghana has instituted many measures to ensure that teacher has the necessary repertoire of pedagogical skills in addition to their content knowledge [34]. This is a result of modern research showing that a teacher's pedagogical skill is a recipe for student academic success. Within the last two decades, teacher training education in the country has seen two significant reforms. The first one was the upgrade of the Teachers Certificate A awarding institution to Diploma status and the latest upgrade from Diploma awarding to degree status in 2018 backed by an Act Parliament. The main agenda was to train teachers who are well equipped in pedagogy and content, especially science, technology, and mathematics. The Colleges of Education are expected to train the pre-service teachers to employ technology in their instructional delivery. With the full implementation of the Colleges of Education Act 2012, Act 847, the Colleges of Education are now entirely new Universities offering degree programs in teacher education. This is a result of the government's commitment to producing

highly sophisticated degree holders with a repertoire of modern pedagogical knowledge and skills and can inspire learning and encourage critical thinking, problem-solving, and creativity at the pre-tertiary schools. This is according to international standards and in line with the Sustainable Development Goal 4 (SDG4); to ensure inclusive and equitable education and promote lifelong learning for all [35, 36].

Moreover, a Non-Governmental Agency (NGO) known as Transforming Teacher Education through Learning (T-TEL) has also adopted the public Colleges of education in Ghana. It is making giant strides in promoting context-based learning. This is to ensure that the pre services teachers have conceptual understanding and are well equipped with modern content knowledge and skills for teaching, especially in mathematics and science [35–37]. In addition to measures being put in place by the government to ensure a smooth transition in school mathematics, a couple of researchers have also added their voices to the need to adopt inquiry-based and problem-solving strategies to ensure that school mathematics is as practical as possible [25, 38–40].

The focus has been on the teacher quality because; the teacher is the primary determinant of what the pupil must know. As posited by [41], the role of the teacher in the classroom cannot be overemphasized since they are at the heart of effective mathematics education. If the teacher adopts child-centered approaches to teaching and learning, the child stands to benefit and learn even more [8]. Mathematics teachers are therefore encouraged to teach using hands-on and mind-on approaches, which learners will find fun and adopt as a culture [40].

It is upon this background that the new curriculum for mathematics in Ghana has been designed to stand on the pillars of the Problem-solving approach, problem-based learning, inquiry methods, and other innovative teaching skills. This is to promote hands-on classroom activities to make what pupils learn in class relevant to real life [6]. The National Teaching Council (NTC) and the National Inspectorate Board (NIB) are state institutions under the Ministry of Education, Ghana, established by law to ensure the professional development of both pre-service teachers and practicing teachers so that they can inspire learning at the pre-tertiary schools in Ghana. Teacher licensing, Teacher Professional Development (TPD), study leave with pay for teachers, and the introduction of promotion examination are a few of the measures in place to ensure quality education delivery in Ghana. The latest to join in the provision of Wi-Fi in most senior high schools to enhance research, teaching, and learning of mathematics at the Senior High Schools.

9. Conclusion

As the world is moving faster due to technological advancement, there is a need for the country Ghana not to remain stuck. International Assessments like the TIMSS and the World Bank Human Capital Index are some of the measures used to determine a country's growth and

development. Even though the country is progressing, international rankings show insufficient effort. Ghana has come a long way and must be ready to enroll back in the TIMSS Assessment as a formidable measure of the gains been achieved in the investment made in education so far. All the best performing TIMSS countries are countries that have developed; this should suggest to Ghana that it is high time they embraced the modern pedagogies in mathematics problem-solving in order to train the young ones to be innovative, creative, critical thinkers and problem solvers, but not just acquisition of paper certificates to chase non-existing jobs.

The students' mathematics results from the West Africa Examination Council have not been satisfactory over the years despite the huge investments. The Ghana Education Service must ensure that the final year examination for both the Junior and Senior High schools conducted by WAEC is in line with the aim and objectives of the mathematics curriculum in Ghana as well as best international practices. It will be better to opt for other mechanisms of assessment with international repute that can help transform the country's school mathematics than to continue with the current monopoly enjoyed by the examination body.

The national teaching council must also intensify the continuous professional teacher development to ensure that the serving teachers are abreast with the modern best practices. Mathematics teachers, on the other hand, should endeavor to have a conceptual understanding of every topic before they teach.

It is also suggested that the National Centre for Curriculum Assessment conducts regular and efficient training for practicing teachers on how to deliver according to the goals and aims of the mathematics curriculum across all educational levels.

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