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PERCEIVED CAUSES OF CANDIDATES' WEAKNESSES IN RIGID MOTION

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ABSTRACT: *The West African Examination Council chief examiners' reports repeatedly indicated that B.E.C.E. and W.A.S.S.C.E. candidates have been exhibiting weaknesses in locating points, plotting points and reading rigid motion graphs, hence the need for the conduct of this study to determine the factors responsible for students' weakness in rigid motion. This qualitative study employed a case study design using a sample size of sixteen (16) comprising five B.E.C.E. candidates, five W.A.S.S.C.E. candidates and six experienced mathematics teachers who have taught mathematics for at least seven years. Purposive and simple random sampling techniques were employed in the selection of the sample size. Interview guide was used to collect data for the study and the collected data was analysed thematically. It was found that little or late exposure of students to the topic, lack of teaching and learning materials and rote learning or memorization were contributory factors to students' weakness in rigid motion. It was therefore recommended that the mathematics curriculum be structured in a way that students will gain the needed exposure in rigid motion and other graph related topics as early as possible. Also, schools, Ghana Education Service, the government, philanthropists and all stakeholders in education should come to the aid of teachers and students by providing graph boards, laptops and projectors for teachers and also providing graph books for students to enable them have frequent practice in rigid motion and other graph related topics.*

KEYWORDS: Rigid Motion, Students Weaknesses, Perceived Causes.

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INTRODUCTION

Mathematics is a fundamental and indispensable discipline that plays a critical role in various aspects of our lives, from science and technology to finance, economics, engineering, and even everyday activities. Its significance stems from its ability to provide logical reasoning, problem-solving skills, and a precise language to describe the world around us. Mathematics serves as the backbone of scientific and technological advancements. It provides the necessary tools for modelling and analysing natural phenomena, making predictions, and developing innovative solutions. From physics and engineering to computer science and data analysis, mathematical concepts underpin the development of theories, algorithms, and technologies that shape modern society (Khare & Badger, 2016).

It also fosters the development of logical reasoning, critical thinking and problem-solving skills. It again trains students to break down problems into manageable units, identify patterns and devise effective strategies to arrive at solutions. These analytical skills extend beyond mathematics and are essential in various professional and everyday life scenarios (Schoenfeld, 1985).

Moreso, mathematics underpins economic theories and financial models, facilitating the analysis of economic trends, risk management, and investment strategies. Concepts like calculus, statistics, and game theory have proven essential in economics, enabling policymakers and financial analysts to make informed decisions (Blanchard, 2006).

In conclusion, mathematics is a cornerstone of human progress and a powerful tool for understanding the world and solving complex problems. Its applications extend across a vast range of fields, making it a crucial subject for education and research. Emphasizing the importance of mathematics in various domains encourages individuals to develop strong mathematical skills, fostering innovation and growth in society. One of the topics in mathematics which appears very examinable and therefore has a significant effect on candidates' performance in both B.E.C.E. and W.A.S.S.C.E. examinations is rigid motion. Rigid motion questions appeared and continue to appear in almost all B.E.C.E. and W.A.S.S.C.E. mathematics examinations and for that matter is seen by many students and teachers as one of the most important and examinable topics in mathematics.

Rigid motion, also known as isometry, is a fundamental concept in mathematics that plays a crucial role in various fields, including geometry, algebra, and physics. It describes transformations that preserve distances and angles between points, maintaining the shape and size of objects. These transformations include translations, rotations, and reflections. The importance of rigid motion in mathematics can be highlighted by its numerous applications and its role in preserving important geometric and physical properties.

For instance, rigid motion is said to be foundational in the finite element method, a numerical technique used to solve partial differential equations and analyse structures and systems. The concept of rigid motion helps in mesh generation and boundary conditions imposition, allowing for accurate simulations (Zienkiewicz et al., 2005).

To say it all, the importance of rigid motion in mathematics cannot be overstated. It provides a bridge between algebraic concepts and geometric intuition and is foundational in many fields that rely on mathematical modelling and analysis. From geometry and group theory to robotics

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and physics, the study of rigid motions offers powerful tools for understanding and solving real-world problems.

Despite the importance of rigid motion in students' performance in mathematics, other disciplines and in real life situations, literature have however shown that students do not find its learning easy and this has contributed to the prevailing poor performance of students in the topic and mathematics as a subject. For instance, Agyei and Benning (2015) noted that students struggle to understand the concept of rigid motion. Asare (2019) also came out with the claim that about 95% of students encountered series of challenges in geometry tasks involving rigid motion. The chief examiners' reports for both B.E.C.E. and W.A.S.S.C.E. for some years now have been reporting that students continued to exhibit weaknesses in reading, locating and plotting points on a graph and therefore suggested that during teaching, emphasis should be placed on showing evidence of reading from graphs (W.A.E.C., 2017; 2018; 2019; 2020; 2021). Also, verbal communication with some of the mathematics teachers in the Kassena-Nankana municipality revealed that most candidates did not do well in the graph related question in the just ended Best Brain mock examinations organized for the 2023 B.E.C.E. candidates. These mathematics teachers in the municipality were contacted to find out how their students are faring in the graph related questions and the feedback revealed that students are not performing as expected in graph related topics. Though W.A.E.C. continues to notify the general public about candidates' weaknesses in locating points, plotting points and reading from graphs, not much is done in terms of research in the Kassena-Nankana municipality to identify the possible causes of candidates' weaknesses in the topic, hence the focus of this study.

LITERATURE REVIEW

Causes of Students Difficulties in Rigid Moton (Graphs)

Students' difficulties in rigid motion and other graph related questions could be attributed to several factors, some of which are as follows:

Lack of graph comprehension skills: Some students may struggle with understanding the fundamental concepts of graphs, such as the x-axis representing the independent variable and the y-axis representing the dependent variable. Difficulty comprehending the relationship between variables and the representation of data on a graph have the potential of hindering learners' ability to locate and interpret points (NCTM, 2000).

Lack or insufficient exposure to graph-based problems coupled with insufficient practice in locating points, plotting and reading graphs can hinder students' ability to develop proficiency in graphing (Willingham & Lloyd, 2007; Hiebert & Grouws, 2007). Limited exposure to graph-related problems and insufficient practice results in lack of familiarity with graphing techniques, making it difficult for students to read and interpret graphs accurately (Remillard, 2005; Rittle-Johnson et al., 2001). Again, insufficient exposure to graph interpretation tasks during early education hinders students' graph-reading skills. Studies suggest that students need repeated practice with various types of graphs to develop the ability to comprehend and draw meaningful conclusions from data visualizations (Chang & Yeh, 2017).

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Furthermore, students may struggle with graph-related tasks if they lack fundamental knowledge in mathematics, such as understanding coordinates, number sense, and basic arithmetic operations. Research by Casey and Heo (2017) indicates that prior knowledge of foundational mathematics concepts is essential for graph comprehension.

Moreso, students may exhibit weakness in rigid motion as a result of weak conceptual understanding. These students may memorize steps without fully understanding the underlying concepts. For instance, they might perform transformation procedures without comprehending why certain steps are taken or the implications of each step. This can lead to difficulties in locating and plotting points accurately (Hiebert & Lefevre, 1986).

To add to that, overemphasis on rote learning and memorization is another factor that can cause students difficulties in rigid motion (Kilpatrick et al., 2001). Students who are encouraged to memorize formulae and procedures without understanding the underlying concept usually struggle to apply their knowledge in different scenarios or fields. Rigid motion requires comprehension, not just rote memorization.

In addition to the above-mentioned factors, teaching approaches employed in class is another crucial factor that can enhance or hinder students understanding of rigid motion. Effective teaching strategies and availability of appropriate teaching and learning resources are crucial for helping students understand geometric concepts and rigid motions (Hiebert et al., 2002). For students to gain deep conceptual understanding of rigid motion, teachers need to use varieties of instructional methods, such as hands-on activities, visual aids, and interactive software, to cater for different learning styles in the mathematics learning environment.

In conclusion, students may face difficulties in locating points, plotting points and reading correctly in rigid motion graphs due to a combination of factors, including the use of ineffective and inappropriate instructional strategies and resources, lack of constant practice, late exposure of students to the topic, and overemphasis on memorization. Addressing these factors through appropriate teaching methods, the use of appropriate teaching and learning resources and constant practice can help students gain a deeper understanding of geometric concepts and improve their skills in rigid motion.

METHODOLOGY

Case study design was employed in this qualitative research to explore and unravel the causes of candidates' weakness in rigid motion questions. The number of participants in the study was sixteen which comprised five Junior High School (J.H.S.) candidates, five Senior High School (S.H.S.) candidates, three S.H.S. teachers and three J.H.S. teachers. The six experienced teachers were purposely selected whilst the ten candidates (one from each school) were randomly selected for this study. The six experienced teachers were chosen on the basis that they are the teachers who have taught rigid motion to several batches of candidates' and probably might have an idea of the weaknesses of candidates in the topic and the possible reason(s) behind candidates' weaknesses.

An interview guide was used to gather the data from the sixteen participants. The interview guide was validated through peer and expert review and the review comments were acted upon to improve the quality of data gathered using the guide. The qualitative data was made

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trustworthy by adhering to the strict criteria by Lincoln and Guba (1985) as cited in Kombat et al. (2023). The credibility of the data was established through a process called “member-checking” in which participants were given access to the transcribed data and asked to verify its accuracy and consistency with their own experience. The services of qualitative researchers were employed in the data analysis process to help guarantee dependability. The data was double-checked at every stage of the collection and processing to ensure confirmability and it was made easy to be transferred to different settings by giving a thorough account of the study’s setting, participants and data gathering process. The data was transcribed, coded and then analysed thematically.

Participants were coded as T1 to T6 for the six teachers and C1 to C10 for the ten candidates to ensure anonymity of respondents. Participants were assured that the data they provide would be treated confidentially and would be used for the research purpose only. The interview was conducted in a serene environment where the process would not be disrupted.

RESULTS AND DISCUSSIONS

In an attempt to unravel the causes of learners’ or candidates’ weakness in rigid motion, all sixteen participants were interviewed and the interview data analysed thematically. From the interview data analysis, it was discovered that three key factors were responsible for the weaknesses candidates and other learners exhibit when attempting rigid motion questions in examinations. One of such factors is lack of appropriate teaching and learning resources needed for doing graph works. It was revealed by all three Junior High School teachers that their schools do not have graph boards and as a result teachers do not use graph boards to teach graphical concepts but rather resort to the use of chalkboards which makes it difficult for them to effectively demonstrate to learners, thereby resulting in ill understanding of the topic by the learners.

On the part of the Senior High School teachers, all three agreed that they have graph boards in their schools but the boards are woefully inadequate for all mathematics teachers to actually make use of while teaching. They again added that some of the few available graph boards are not in good condition for teaching and learning. When teachers were asked if they have been making good use of the Geogebra software in teaching rigid motion and other graph related concepts, it was realized that most teachers do not have laptops, majority of teachers had little or no knowledge on how to use the software, and the few with laptops and expertise in the software usage do not also have projectors, making it practically impossible for teachers to enhance learners’ understanding of the topic using the software. The teachers again mentioned that most of the learners come into the mathematics learning environment without graph books and mathematical sets and that learners have been answering graph questions in their exercise books. This finding supports Hiebert et al. (2002) who noted that the availability of appropriate teaching and learning resources is crucial for learners’ success in graph related problems. Below are excerpts from the interview:

T1, T2, T3: *We do not have graph boards, laptops and projectors for graph works and learners too do not come to school with graph books and mathematical sets.*

T4, T5, T6: *We do not have enough graph boards in the schools and some of the available ones are not fit for this purpose. Some of us have laptops and could have employed the services of*

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the Geogebra software in the teaching of rigid motion but there are no projectors in the schools.

The second factor responsible for learners' weaknesses in rigid motion is late exposure of learners to the concept of graph (rigid motion) coupled with insufficient practice. It was found that learners were not introduced to the graphical concepts at the early stages of their educational journey but rather at the tail end of their Junior High School education. Most learners are usually introduced to the concept of rigid motion just when they are about to write their mock examinations and B.E.C.E. Not just were they introduced to the topic late, but they equally did not practice solving enough and diverse problems in the topic for them to gain deeper understanding and familiarize themselves with rigid motion problems due to limited time. This finding agrees with Remillard (2005) and Rittle-Johnson et al. (2001) when they found that limited exposure to graph-related problems and insufficient practice resulted in lack of familiarity with graphing techniques, making it difficult for students to read and interpret graphs accurately.

Below are excerpts to that effect:

C1, C5, C8: *These candidates mentioned that they were introduced to rigid motion in Junior High School 3 just some few months to the B.E.C.E.*

C3, C9, C10: *These candidates said that they did not practice solving more questions on rigid motion in class due to the limited time that was left between the time of introduction of the topic and their final examinations.*

The last but not the least factor which caused candidates weakness in rigid motion is the overemphasis on memorisation by the teachers. It was realised that most of the teachers have been encouraging rote learning in the mathematics class by making learners memorise formulae instead of teaching for conceptual understanding of mathematical concepts. It was again found that learners could not derive the formulae for reflections by themselves; they could not also use the graph to reflect or rotate points and shapes, meanwhile some of these learners could memorise all the formulae for reflections and rotations. The fact then is that, if these learners accidentally forget the formulae in the examination hall, it becomes a mess for them and since they lack the conceptual understanding of the topic, it becomes difficult for them to reconnect with the lost formulae and when that happens, the learner would eventually perform poorly in that question. This finding is in line with Kilpatrick et al. (2001) who found that overemphasis on rote memorization caused learners difficulties in rigid motion.

Some excerpts from the interview are shown below:

C3, C6: *These candidates said that their teachers gave them all the formulae in the topic and asked them to take note of them since they will be using those formulae to solve rigid motion questions.*

C2, C7: *These candidates responded that their teachers asked them to memorise all the rigid motion formulae and apply them appropriately when answering questions on rigid motion*.

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IMPLICATION OF THE STUDY

The findings in this investigation implied that for the country to achieve a zero candidate's weakness in rigid motion in the B.E.C.E. and W.A.S.S.C.E. mathematics papers, there is a need for effective collaboration among all the necessary stakeholders in education. For instance, the government through the ministry of education, non-governmental organisations, Ghana education service, philanthropists and parents need to collaborate in the provision of appropriate teaching and learning resources such as graph boards, markers, laptops and projectors for teachers, and graph books with a pair of mathematical set for learners to use during their engagement in graph related works. Also, curriculum developers need to ensure that the curriculum is designed in a way that will expose learners to rigid motion and other graph related topics as early as possible whilst teachers ensure that they employ appropriate teaching methods and materials that will give learners the opportunity to visualise and develop the skills needed for locating points, plotting points on a graph and the reading of graph in general.

CONCLUSION

Based on the research findings, it was concluded that lack of appropriate teaching and learning resources, late exposure of learners to the topic coupled with little practice and overemphasis on memorisation are the causes of learners' weaknesses in rigid motion and graph related questions.

SUGGESTIONS FOR FUTURE RESEARCH

The researchers suggest that similar investigations be carried out in other districts/municipal assemblies and regions in the country and beyond to assess the situation in those locations since the issue of candidates' weaknesses in rigid motion had always been a national issue.

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