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Analytical Study on the Impact of Teaching-Learning of 'Transformation Geometry' in Secondary Schools in General using Van Hiele's Model

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Abstract
An analysis of the methods involved in the teaching-learning of the topics related to Transformation Geometry' is one of the topics in mathematics in which learners have not been performing very well. The purpose of the study is aimed to identify the difficulties of the learners encounter when learning transformation geometry using Van Hiele's model. Data was analysed through a process of coding, categorizing, clustering and performance indicators corresponding to the Van Hiele's model were used in the analysis of data. The result of the study indicated that learners, experienced difficulties to solve problems involving enlargement transformation geometry problems. Learners struggle to grasp the fundamental concepts of enlargement, particularly with the concept of the centre and scale factor. The study findings revealed the challenges faced by the students in comprehending geometrical figures that were transformed to a larger dimension. The Learners inability to understand the steps of transformation geometry because they had insufficient background knowledge on the topic is taken to relevance in this paper writing. The study focuses on the limitations, challenges and remedies being intended for better learning prospects.
Keywords: Difficulties, Enlargement Transformation, Van Hiele's model, Prior Knowledge

Introduction

Interesting aspect of Mathematics education as a related comprehension relies heavily on 'Transformation Geometry', a fundamental concept that fosters spatial reasoning, visualization, and problem-solving skills in learners. Despite its importance, learners often struggle to comprehend the abstract concepts and principles underlying Transformation Geometry, resulting in poor performance. Identifying the specific difficulties learners encounter is crucial in developing targeted instructional strategies to address these challenges. Van Hiele's model, a theoretical framework that describes the levels of geometric thinking, offers a valuable tool for examining learners' understanding of Transformation Geometry. This study applies Van Hiele's model to analyze learners' difficulties, focusing on enlargement transformations, with the goal of informing the development of effective instructional approaches and materials that support learners in overcoming these challenges and achieving a deeper understanding of Transformation Geometry.

Background of the Study

Basing on the content analysis in Zambian context, it is identified that the examiners', findings indicated that the majority of students performed well in questions related to statistics and geometric graphs, but struggled with questions concerning transformations, trigonometry, and earth geometry. Additionally, ECZ stated that 'Transformation Geometry' was the geometry topic where pupils showed lower performance, in comparison to other geometry topics. Still, the primary objective of high school geometry is to cultivate in students the ability to think mathematically and effectively tackle real-world issues by staying attuned to their surroundings. This implies that students may not have sufficient development of geometric abilities, such as visualizing, rotating, sliding, reflecting, enlarging, shearing, and stretching an object which are crucial for understanding Transformation Geometry and other geometric ideas.

Van Hiele's study can help explain and understand the difficulties students face in Enlargement Transformation Geometry. Van Hiele's study was influenced by Piaget, who had previously established four stages of cognitive growth known as the sensorimotor stage, preoperational stage, concrete operational stage, and formal operational stage. Van Hiele's Model mainly concentrated on five stages of geometric understanding: visualization, analysis, abstraction, deduction, and rigor. (Van Hiele) proposed that learners progress through various stages of geometric thinking.

Van Hiele's discoveries on geometric conceptualization were utilized to clarify why numerous high school students were facing challenges in learning geometry. Literature also showed that the levels of geometric understanding in Van Hiele's model were an effective way to assess students' preparedness for formal geometry lessons.

Purpose of the Study

This study aims to identify the difficulties of the student faced when learning enlargement of shapes through the procedures of transformation geometry and with a focus on the Van Hiele Model of geometry learning. More emphasis is given to the student's comprehensibility and adaptability to the features of 'Transformation Geometry'.

Objectives of the study

This study aimed to achieve the following objectives

1. Identify the difficulty levels of student when learning transformation geometry.
2. Investigate the challenges of the student when solving problems in transformation geometry.

Research Questions

The following research questions were achieved by the study's objectives.

1. How do pupils perceive the difficulty of transformation geometry?
2. What are the factors students faced when solving the problem in transformation geometry?

The Scope

The study looks into the obstacles that students have when learning transformation geometry, such as the abstract character of the ideas, the dearth of practical applications, and problems with spatial reasoning. The research design is based on surveys, interviews, and in-person observations of students and teachers and that will be used in this paper in order to learn more about the main issues that students experience and thereby to find workable solutions. The study's ultimate objective is to identify the fundamental difficulties that students have when learning transformation geometry and to offer instructors useful suggestions for improving their students' spatial domain geometry learning experiences. The purposive deliberation of this paper is to enhance teaching-learning initiatives to transformation geometry.

Literature Review

Literature review gives the pretext and the aptness for the expressive ideology of this paper with supportive identities as taken to reference. It deals with the research reliance that states on students' comprehension and acquisition of transformation geometry is scarce (Bansilal and Naidoo). Accordingly, (Edwards) clarified that 'Transformation Geometry' gave students a chance to hone their geometrical reasoning and spatial visualization skills. Transformation Geometry is a subset of geometry where students learn to recognize and depict the movement of shapes, according to (Ilaslan), Transformation Geometry is an engaging method of teaching geometry that combines traditional methods and technology use with practical exercises involving real-world objects.

In accordance to the stated facts of Edexcel, to complete the tasks of 'Enlargement' in Transformation Geometry, students must be able to recognize a transformation, locate the center and scale factor of the enlargement and use them to perform an enlargement, as well as describe the enlargement using appropriate terminology and sound reasoning.

The study also found that the students held false beliefs about introspection. In this instance, the students mistook congruent properties of shapes for similarity. (Aktas and Unlu) also noted that the students struggled to find and use the angle and center of rotation, as well as to recognize and write the equation for the axis of symmetry of shapes under reflection. Additionally, (Ada and Kurtulus) looked into the misconceptions and mistakes made by students in transformation geometry with reference to the researchers' analytical geometry course. Information was gathered from test questions. The analysis's findings demonstrated that these students were ignorant of the geometric significance of these ideas as well as how to apply rotational transformation.

In a related study, (Hollebrands) examined how students conceptualized translation, reflection, rotation, and enlargement as geometric transformations. The investigation took place in the context of the Geometer's Sketchpad, a technological tool that allowed students to analyze geometric transformations as functions. Furthermore, it has been noted that the lack of length conservation in students who are nine, eleven, and thirteen (9, 11 & 13) years old-a level of proficiency that is expected of them is the reason for their poor performance on the transformation tasks. In order to improve geometric thinking activities, author (Idris) argued that geometry instruction needed to promote more unconventional problem-solving techniques like geometric puzzles and problems based on actual scenarios. In order to improve mathematical communications, it was necessary to incorporate additional opportunities for interaction between educators and students into the design of geometric instructions.

Theoretical Framework

The study's results were described and explained using the Van Hiele model. According to (Corley), students' preparedness for formal geometry instruction can be accurately assessed using the geometry comprehension levels found in Van Hiele's model. Based on Piaget's work, Van Hiele's research mainly examined five stages of geometric conceptualization. In his book 'Teaching Children Mathematics', Van Hiele proposed that students progressed through different levels of thinking when studying geometry.

The five levels of comprehension of geometry is identified in Van Hiele's model, which are as follows:

Level 1 - Visualization: Illustration at this level, students concentrate on the appearance and spatial relationships of shapes as well as other visual properties. They may not comprehend the properties or relationships of shapes, but they are able to identify them based only on their visual characteristics. It's possible that students won't be able to recognize shapes with varying sizes or orientations.

Level 2 - Analysis: At this level, students start to examine attributes of shapes such as symmetry, angles, and number of sides. They are able to recognize and explain the fundamental characteristics of shapes, such as how many sides a polygon has or how many right angles it contains. Although they may still rely on visual cues, students are beginning to grasp shapes in a more analytical way.

Level 3 - Abstraction: At this level, students are able to comprehend the relationships between shapes and abstract geometric concepts from specific examples. They are able to define shapes in terms of their characteristics and comprehend the relationships between these characteristics. Pupils start to grasp geometry in a more formal and abstract way, defending their conclusions with definitions and theorems.

Level 4 - Deduction: At this level, students are able to solve problems and prove geometric theorems through deductive reasoning and reasoning. They are able to comprehend the connections between various geometric concepts and apply geometric concepts to solve challenging problems. At this level, students can use their deep understanding of geometric structures to support their arguments.

Level 5 - Rigor: Pupils at this level can solve difficult, abstract problems because they have a thorough and formal understanding of geometric concepts. Higher-dimensional spaces and non-

Euclidean geometries are examples of sophisticated geometric ideas that they can comprehend and manipulate.

Hence the challenges experienced by pupils in enlargement in transformation geometry could be explained and understood better by reflecting on the research work done by Van Hiele based on the sequential stages of geometry learning. This sequenced analysis, as featured by Van Hiele has given an extended initiative to the plan of work as adapted by teachers of Mathematics, to make teaching of transformation geometry to the students interesting and motivating.

Significance of the study

Geometric transformations including translation, rotation, reflection, and dilation are the subject of transformation geometry that encompasses an important area of Mathematics. In order to assist educators in creating successful teaching methods and enhancing students' learning results in designing a crucial area of Mathematics of greater relevance to the study of transformation geometry. Nevertheless, the study intends to investigate these issues in detail.

The abstract nature of the concepts involved in transformation geometry is one of the key challenges that students face when learning it. Pupils frequently have trouble picturing and comprehending these changes, which causes misunderstandings and makes problem-solving challenging. Through the identification and resolution of these conceptual obstacles, teachers can assist students in building a strong foundation in transformation geometry.

One of the biggest obstacles that students have when studying Transformation Geometry is the dearth of practical applications and significance. By incorporating hands-on activities and real-world scenarios into the curriculum, teachers can increase students' motivation and comprehension of Transformation Geometry by making the material more interesting and meaningful.

Additionally, some students may find it difficult to understand rationally and spatially due to the abstract character of Transformation Geometry. It can be difficult for students to mentally see transformations, comprehend the mathematical principles that underpin them, and use these ideas to solve problems precisely. Teachers can assist students in improving their performance in transformation geometry and developing their spatial reasoning abilities by giving them plenty of practice opportunities, visual aids, and problem-solving assignments.

Research Design

A case study design was used in the study's qualitative component, which entailed a thorough analysis of a limited number of individuals. This design helps to provide a thorough knowledge of the experiences and thought processes of the students learning Transformation Geometry.

Data Collection Methods

The qualitative data was collected through the follow systems of information gathering:

Semi-structured Interviews: In-depth interviews were conducted with a purposive sample of pupils to gather data on their thinking processes, experiences, and perceptions of learning transformation geometry.

Classroom Observations: The researcher observed pupils during transformation geometry lessons to gather data on their interactions, behaviors, and problem-solving strategies.

Data Analysis Procedure

The interview questions was developed based on Van Heile's model as frame work with constructed the questions designed to reveal the student's thought process and experience of the various tires of geometric reasoning. The findings are presented according to the research objectives.

Difficulties encountered by pupils in solving Enlargement Transformation problems was based on the questions reflected as below:

Question 1: Transformation mapping triangle R onto triangle X

Question 2: Enlarge triangle

Questions 3: Transform triangle ABC under enlargement about the centre and

Question 4: The centre and scale factor in enlarging a figure

The factual analysis related to the topic of the paper writing is well-sufficed to the responses taken from the sample space. The derivatives from the responses will be the relative findings of the paper.

Analytical Relevance to Identified structures

Figure 1 presents the results of the written test on pupils' difficulties in solving enlargement transformation geometry problems.

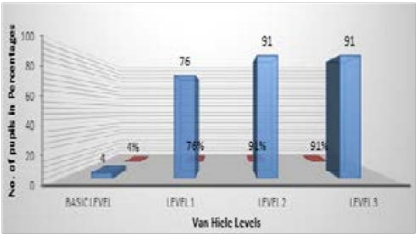

Figure 1: Learner's Difficulties based on Van Hiele's Levels

Figure 1 shows that 4 out of the 100 pupils (4%) had difficulties at the level of visualisation (linked to question 1:transformation mapping triangle R onto triangle X), 76 (representing 76%) pupils experienced difficulties at descriptive level (linked to question 2:enlarge triangle) and the levels of deduction and abstraction were at par, with 91 pupils (representing 91%) having experienced difficulties at these levels (linked to questions 3:transform triangle ABC under enlargement about the centre and question 4: the centre and scale factor in enlarging a figure respectively). It is noticed that most of the grade 12 pupils at the two schools were reasoning at the lowest level (visualisation) of the Van Hiele's model. The results show that the grade 12 pupils had problems and difficulties in solving enlargement transformation geometry especially with those problems of higher order levels (description, analysis and deduction) of the Van Hiele's model of geometry thought.

Root Causes of the Challenges that Pupils face in Solving Issues of Enlargement in the Problems of Transformation Geometry Problems

From the pupils' point of view, the researcher embarked on trying to establish, from the pupils themselves, the challenges that they faced in solving concepts of enlargement in transformation geometry problems. The researcher interviewed 6 of the pupils who experienced more difficulties during the written test so that he could have a clear and in-depth understanding of the results at hand. The questions asked during the interview session were focused on the areas they experienced problems with during the written test. Each pupil was given a piece of paper, a pencil and a pen. They were required to explain, verbally or in writing, how they arrived at their answers and they could also give reasons for their answers.

All the six pupils interviewed were able to recognise the figure as an enlargement but had difficulties in describing the enlargement fully. They also expressed challenges with a question which required them to transform triangle ABC about the centre with scale factor -2 and explaining the steps they took to obtain the image. For example, student B15 said that the transformation was enlargement and kept quiet. However, the researcher requested him to use the properties of the centre and scale factor of enlargement to fully describe the transformation, but he remained quiet and shook his head indicating that he did not know the process fully.

Findings from the interview on the use of the terms centre and scale factor to describe the transformation mapping triangle R onto triangle X revealed the following findings.

Pupil B15: *'Maaa-aa! I don't know, I only know that triangle R has been made bigger into triangle X.'*

Pupil G21: *'I know that there should be the centre and scale factor to enlarge a figure, but I don't know how to find them or describing enlargement now….' 'Besides that, our teacher told us that transformation is not important and we should not answer a question on transformation in our final examination.'*

Other respondents failed to even understand the question they wrote in the test. This can be confirmed from one interviewee's response when he was asked to enlarge triangle ABC about the given centre (1.5, 1) with scale factor -2. He stated

Pupil B30: *'What do you mean sir?'*

The interviewer clarified that he meant the steps the student would follow to transform triangle ABC under enlargement about the centre (1.5, 1) and with the scale factor (-2). The response was that:

Pupil B30: *'Oh… you move each point two steps away from the centre to find all the points on the image. But here sir, do not ask me another question please because these things confuse me a lot.'*

Another pupil had this to say on the same question:

Pupil B31: *'I have to move it to here (pointing at the position calculated, but an incorrect one).'*

The interviewer probed further by asking if it was the same procedure he used to obtain the image of point A.

Pupil G31: *'Yes'*

The researcher asked the pupil to transform points B and C using the same procedure she followed to transform A.

Pupil G31: *'Okay sir…. But it looks like something else again.'*

The demonstration she showed resulted into an incorrect image of triangle ABC.

The researcher asked why there was a need for the centre and scale factor in enlarging a figure.

Pupil G31: *'I think I am not sure here, help me, please.'*

The respondent could only manage to give a relevant response after she was guided on what to do.

The results showed that when addressing enlargement of geometric shapes as indicated in the transformation geometry problems, the majority of students found it extremely difficult to determine the center and scale factor of enlargement. Most students found it challenging to construct an image under enlargement using the scale and center factors. Furthermore, they had trouble understanding how to relate the idea of enlargement to geometrical evidence and mistook the original figure for its transformed counterpart. The students also showed a lack of comprehension of proportionate sides, size, and shape, in addition to being ignorant of some important geometry words.

Conclusion and Recommendations

According to the study, most students found it harder as transformation geometry problems got bigger in scale. In addition, the majority of students found it difficult to solve geometry problems involving enlargement transformations, which included figuring out the enlargement's center and scale factor as well as creating an enlarged image. The research also revealed that the majority of students struggled to identify the relationship between the figure and its transformed image when using the concept of enlargement to perform geometrical proofs. In keeping with this, the students showed a lack of understanding of the concepts of proportionate sides, size, and shape.

The study also revealed that students struggled to understand the terminology used in geometry, which prevented them from applying these terminologies when describing figures that were enlarged. The study's final findings indicated that most students were not exposed to more geometrical problem-solving scenarios and lacked sufficient and pertinent prerequisite knowledge for application of the scale for enlargement as denoted in the problems of transformation geometry.

Recommendation

Based on the findings of this investigation, the ensuing suggestions were put forth to address the current problems:

Instructors should make an effort to inspire students' interest in the subject and provide them with the background information they need to understand enlargement transformation. This should involve exposing students to real-world scenario-based problem-solving exercises that call for explanation as well.

The mathematics curriculum in secondary schools should be adapted to the different levels of thinking and should teach students important and useful concepts that will force them to justify and explain their conclusions and develop their critical thinking skills.

Teachers ought to be equipped with cutting-edge methods and resources so that students can grasp transformation geometry concepts with ease through visual aids, interpretations, and actions. This will be beneficial.

Suggestions for further investigation can be taken in relational identity to the relevance of geometry and geometrical language in the learning of transformation geometry. This study may give greater impetus to creative designing and plan lay-out that can be formulated for the futurity to practice.

Specified Aspects taken in Finale

The effectiveness of teaching enlargement in Transformation Geometry in Zambian context is that it helps students understand spatial reasoning scaling and geometrical properties. These aspects in Transformation Geometry lays that needed foundation in learning subject like Engineering and Architecture.

- Teacher while teaching the subject should use visual aids and models, they can as well use digital tools or software related to Transformation Geometry. Teachers need to use local examples that can resonate with pupil everyday life on observation of 'Enlargement'.
- Teacher to discuss enlargement of designs and figures in buildings and geological maps which are done using a scale.
- Group activities and group work can be initiated to encourage students understand the concepts of enlargement in transformation geometry more precisely.
- Students to be allowed to share different perspectives in solving problems in transformation geometry.
- Challenges faced may be due to limited resources specifically to the need of teaching aids and computers with digital software.
- Most importantly, teachers need to prepare well with concepts of Transformation Geometry before forwarding the lesson to their students. Teacher preparation is prior along with professional development opportunities extended to them.

Conclusively, it can be well adjudged that the study on Transformational Geometry is an eye-opener to the conceptualized identity of teaching and learning of geometry in schools and in tertiary educational systems.

References

Ada, Tuba, and Aytac Kurtulus. "Students' Misconception and Errors in Transformation Geometry." *International Journal of Mathematical Education in Science and Technology*, vol. 41, no. 7, 2010, pp. 901-09.

Aktas, Gulfem Sarkaya, and Melihan Unlu. "Understanding of Eight Grade Students about Transformation Geometry: Perspectives on Students, Mistakes." *Journal of Education and Training Studies*, vol. 5, no. 5, 2017.

Bansilal, Sarah, and Jayaluxmi Naidoo. "Learners Engaging with Transformation Geometry." *South African Journal of Education*, 2012.

Clements, D. H., and M. Battista. "Geometry and Spatial Reasoning." *Handbook of Research on Mathematics Teaching and Learning*, Macmillan Publishing, 1992.

Corley, Leroy. *Students' Levels of Thinking as related to Achievement in Geometry*. Arizona State University, 1990.

Cresswell, J. W. *Qualitative Inquiry and Research Design: Choosing among Five Traditions*. Sage, 1998.

Denscombe, Martyn. *The Good Research Guide: For Smallscale Social Research Projects*. McGraw-Hill Education, 2007.

Edwards, Laurie D. "Children's Learning in a Computer Software for Transformation Geometry." *Journal for Research in Mathematics Education*, vol. 22, no. 2, 1991, pp. 122-37.

Hollebrands, Karen. "High School Students' Understanding of Geometric Transformations in the Context of a Technological Environment." *The Journal of Mathematical Behavior*, vol. 22, no. 1, 2003, pp. 55-73.

Idris, Noraini. *Spatial Visualization, Field Dependence / Independence, Van Hiele Level, and Achievement in Geometry: The Influence of Selected Activities for Middle School Students*. The Ohio State University, 1998.

Ilaslan, S. *Middle School Mathematics Teachers' Problems in Teaching Transformational Geometry and their Suggestions for the Solution of these Problems*. Middle East Technical University. 2013.

Jones, K. "The Value of Learning Geometry with ICT: Lessons from Innovative Education Research." *Mathematics Education with Digital Technology*, Continuum, 2011.

Van Hiele, Pierre M. "Developing Geometric Thinking through Activities that Begin with Play." *Teaching Children Mathematics*, 1999.

Zorin, Barbara. *Geometric Transformations in Middle School Mathematics*. University of Florida, 2011.

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