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Impact of the Know-Want-Learn (KWL) Strategy on Geometry Performance Among Upper-Basic Students in Nigeria

Kazaik Danlami [1] *, Umar A. Ginga [2], Aliyu S. Aliyu [3],

Ramatu Ematum Umahaba [4], Muhammad Tsoho [5]

Abstract

Due to the ongoing difficulties in teaching mathematics, especially geometry, in Nigerian schools, new teaching methods are needed to improve student performance. This quasi-experimental research examined how the Know-Want-Learn (KWL) method impacts the geometry performance of upper-basic students in Kaduna North, Nigeria. Two questions were posed for research, and two void hypotheses were examined. The study included 98 students selected from a population of 6300 upper-basic students in Kaduna North. They were split into two groups: an experimental group (n=50) that was taught using the KWL strategy, and a control group (n=48) that received instruction using traditional methods. The researcher created a 28-question multiple-choice Geometry Performance Test (GPT) with a reliability coefficient of 0.86, as determined by Cronbach's alpha. Students were tested before and after to determine how well they performed in geometry. The results showed that the experimental group performed significantly better than the control group, with an average score of 23.52 in the post-test, compared to 14.69. ANCOVA analysis revealed a significant impact of the KWL technique on students' achievement ($F=242.518$, $p<.001$), explaining 74.5% of the variability (partial $\eta^2 = .745$). Additionally, there were no significant differences between male ($M = 19.40$, $SD = 5.304$) and female ($M = 18.93$, $SD = 5.045$) students in the experimental group, $t(96) = 0.444$, $p = 0.658$.These results indicate that the KWL approach promotes a more profound comprehension and involvement in geometry, and utilizing it could enhance mathematics teaching in Nigerian schools with equality across genders. It is advised to use the

[1] **Kazaik Danlami,** Department of Science Education, Ahmadu Bello University Zaria Kaduna State Nigeria, ORCID: 0009-0003-1164-0644

Correspondence: bkazaik@gmail.com

[2] **Umar A. Ginga,** Assoc. Prof. Dr., Department of Science Education, Ahmadu Bello University Zaria Kaduna State Nigeria, uaginga2@yahoo.com

[3] **Aliyu S. Aliyu,** Dr., Department of Science Education, Ahmadu Bello University Zaria Kaduna State Nigeria, abusufwan622@gmail.com

[4] **Ramatu Ematum Umahaba,** Dr., Department of Science Education, Ahmadu Bello University Zaria Kaduna State Nigeria, lilianumahaba@yahoo.com

[5] **Muhammad Tsoho,** Dr., Department of Science Education, Ahmadu Bello University Zaria Kaduna State Nigeria, muhammadantsoho2@gmail.com

KWL strategy for teaching geometry in co-ed and single-sex schools and to organize teacher training sessions and seminars to encourage its adoption by math educators.

Keywords: Know-Want-Learn strategy, Geometry Performance, ANCOVA, Upper-Basic students, Mathematics Education.

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INTRODUCTION

Education is the fundamental service provided by society to prepare the upcoming workforce. The objective of education should align with the evolving demands of the world. The concept of active learning, which emphasizes a learner-centred approach, has gained significant interest in the research literature (Doolittle et al.,2023; Lombardi et al., 2021; Fixen & Wald, 2021). It has been validated empirically as the best teaching practice to promote learning for students in the present era (Freeman et al., 2014). According to Bassey, Joshua, and Asim (2011), mathematics serves as a fundamental tool that facilitates the understanding and utilization of science and technology. Having a strong command of mathematical principles and concepts is essential for driving development and advancement across societies globally. Mathematics gives people the skills to analyze and connect numbers and ideas. It provides the basic knowledge needed to effectively use scientific and technological advances. Salman and Adeniyi (2012) stated that Mathematics is the foundation of science, and science is the foundation of technology, and without technology, there wouldn't be a modern society. This is because of the critical role mathematics plays in science, technology, and overall national development (Etsu & Manko, 2019). However, the teaching and learning of mathematics in secondary schools in Nigeria has been facing various challenges and problems. These problems make the subject seem difficult for students and make it challenging for them to perform well in internal and external examinations. A significant issue is the lack of qualified mathematics teachers, leading to inadequate instruction and student comprehension. This problem is compounded by the scarcity of essential teaching resources, such as textbooks and digital tools, and poor classroom conditions, which impede effective learning. Additionally, the reliance on traditional, lecture-based teaching methods often focuses on rote memorization rather than fostering a deep understanding of mathematical concepts, making the subject seem abstract and irrelevant to students. This approach, combined with widespread mathematics anxiety and negative societal attitudes, further discourages students from engaging with the subject. Moreover, insufficient parental and community support exacerbates these challenges, as students may lack the encouragement and motivation needed to excel in mathematics. These issues collectively create a difficult learning environment, making it challenging for students to perform well in both internal and external examinations.

The promising potential of the KWL strategy in enhancing metacognition within mathematics education highlights the importance of integrating metacognitive strategies into the classroom. However, successfully implementing such strategies requires more than just an understanding of their theoretical benefits; it also demands careful consideration of the practical challenges educators face, such as how to effectively engage students and how to measure the impact of these strategies on student learning outcomes. The metacognition strategy is a significant approach to teaching mathematics as it focuses on developing students' awareness and regulation of their thought processes. Metacognition, which emerged from Flavell's research in the 1970s, refers to the understanding and management of one's thoughts (Kuhn & Dean, 2004). It involves higher-order skills such as controlling, monitoring, and reflecting on one's thinking, making it more challenging to teach than cognitive strategies (Pandya, 2015). One metacognitive strategy that has gained attention in mathematics education is the know-want-learn (KWL) strategy. The KWL strategy, representing Know, want to Know and Learned, is an effective teaching approach based on constructivist learning beliefs. It promotes students' active involvement during the learning (Widyari et al., 2022; Fajri, 2015; Alsalhi, 2020; Sari et al., 2023). The strategy consists of three components:

1. Know: Students reflect on what they already know about a topic.
2. Want to Know: They identify questions or areas of curiosity they want to explore.
3. Learned: They summarise what they have learned after the lesson.

To implement the KWL method in the class, teachers must begin by presenting the subject matter. Afterwards, students will make a KWL chart consisting of three columns named "K," "W," and "L."

Students will generate ideas and list their existing knowledge about the subject in the initial column. This initial contemplation triggers their understanding and sets the foundation for additional investigation. Following that, students will inquire about their desired knowledge in the "W" section. This procedure not only sparks interest but also assists them in establishing learning goals. Teachers should motivate students to participate actively in the lesson by incorporating activities that focus on answering their inquiries (Dogani, 2023). This may include conversations within a group, practical activities, or challenges that require solving problems. It is crucial to take breaks during the lesson for students to review their KWL charts and determine if they are answering their questions or if new ones have emerged. Following the lesson, students will fill out the "Learned" part of the chart, summarizing their findings. After the reflection, students will participate in a class discussion to share insights and link their new knowledge to their initial understanding and questions. These conversations help build a feeling of togetherness and cooperative education (Yustisia et al., 2023).

The KWL strategy offers multiple advantages by improving metacognitive awareness as students develop their ability to regulate their learning processes (Tok, 2013). Students who assume responsibility for their education can develop into more self-reliant learners (Biplob et al., 2017). Moreover, KWL's cooperative environment encourages collaboration and social engagement among students. By linking existing knowledge to new ideas, the KWL strategy boosts motivation and involvement, resulting in a more significant learning experience (Usta & Yılmaz, 2020; Nanda & Pratama, 2021). Essentially, the KWL teaching method enhances students' critical thinking by combining cognitive and metacognitive strategies (Dolati Miandoab, & Farrokhi, 2019).

Geometry, which explores shapes, lines, and spatial connections, can be traced back to ancient civilizations. In historical and modern contexts, this area of mathematics is important and can be made more interesting and approachable for students using innovative teaching methods like the KWL strategy. Through the utilization of KWL, educators can link students' existing understanding of fundamental shapes and patterns (Know) with the more complex geometric ideas they are interested in exploring (Want to Know). After studying Euclidean geometry and the practical applications of geometry, students can reflect on their newly acquired knowledge, enhancing their understanding and respect for this ancient mathematical field. KWL promotes active learning in geometry as well as in other math subjects (Jayantika & Diansari, 2023; Babah et al., 2023; Danlami et al., 2024). The development of geometry can be traced through several progressive stages, starting with the foundational concepts of points, lines, and planes, and later progressing to the exploration of two-dimensional (2D) and three-dimensional (3D) shapes (Turgut et al., 2022). Points, represented by dots, are the most basic geometric elements, defined as locations in space without any size or dimension. Lines are straight paths extending infinitely in both directions, formed by connecting two points and possessing length but no width or depth. Planes are flat, two-dimensional surfaces that extend infinitely in all directions, often conceptualized as a "sheet" or "tabletop," and can be defined by three non-collinear points or a line and a point, not on that line. Two-dimensional shapes, such as triangles, rectangles, circles, and polygons, are flat figures confined within a plane, created by connecting lines or combining other 2D shapes. In contrast, three-dimensional shapes, including cubes, spheres, pyramids, and cylinders, possess depth or thickness, existing in three dimensions: length, width, and height. These 3D shapes are formed by combining points, lines, and planes in various configurations.

The study of geometry involves analyzing the properties, measurements, and relationships of these geometric elements, encompassing concepts such as angles, areas, volumes, symmetry, and transformations. It is noteworthy that the development of geometry was a gradual process, with significant contributions from ancient civilizations like the Egyptians, Babylonians, and Greeks, particularly the renowned mathematician Euclid. These early mathematicians and philosophers laid the foundation for the geometry we study today. Over time, geometry has evolved and expanded, incorporating new concepts and applications in various fields, including science, engineering, and art. As Pereira, Wijaya, Zhou, and Purnama (2021) state, "Geometry is any shape seen as a set of specific set points, whereas a plane means a collection of all lines."

Despite the crucial significance of geometry in fostering mathematical reasoning, and problem-solving skills, and its widespread applications across various academic disciplines (Hassan, 2010; Russell, 2014; Ajai & Ogungbile, 2023; Sulistiowati et al., 2018; Sunzuma et al., 2012), student performance in geometry has persistently been unsatisfactory, as evidenced by the poor results in external examinations conducted by the West African Examination Council (WAEC) and the National Examination Council (NECO). Creative tasks in mathematics education result in better performance than imitative tasks, as students use more effective strategies (Norqvist et al., 2019). One of the main reasons for this lower performance is the ineffective teaching methods and strategies used by mathematics instructors, who often depend on the traditional chalk-and-talk approach (Festus, 2013; Motseki et al., 2023). This conventional method promotes rote learning and fails to actively engage students in the learning process (Nwoke, 2015; Aydisheh & Gharibi, 2015). Furthermore, it disregards students' prior knowledge and experiences, impedes their social development, and has proven inadequate in enhancing academic performance in geometry. Gender is the societal portrayal of traits associated with females, males, and youth. This includes guidelines, behaviours, and responsibilities associated with being a woman, man, girl, or boy, as well as relationships between them.

Gender is a social construct that varies among societies and can change over time (World Health Organisation [WHO], 2024). Our traditional comprehension of gender is influenced by three primary perspectives: biological, social, and cultural viewpoints. Put simply, our biological sex is decided by a particular group of genes we inherit when we are born, which typically leads to either male or female traits (Wei, 2013). Gender is highly important in influencing how students interact with the learning process. Studies indicate that gender variances have an impact on students' views, involvement, and achievement in fields such as mathematics, where societal norms can lead to disparities in experiences among male and female students (Wrigley-Asante et al., 2023; Anokye-Poku & Ampadu, 2020). Utilizing approaches such as KWL can aid in closing this divide by promoting balanced involvement and nurturing a student-focused atmosphere where both males and females are comfortable sharing their understanding, inquiring, and evaluating their educational achievements (Ijeoma et al., 2024; Aseer, 2020). Through the utilization of KWL to enhance metacognitive awareness, educators can combat gender biases in the classroom and establish a learning environment that is inclusive and supportive of all students, regardless of gender, in their pursuit of achievement (Kumari & Jinto, 2014). Consequently, there exists a pressing need to explore alternative instructional strategies that can address these deficiencies and provide equal opportunities for both male and female students to acquire, retain, and demonstrate proficiency in geometry. This article aims to investigate the Impact of the Know-Want-Learn (KWL) strategy as a potential solution to improve students' academic performance in geometry in upper-basic schools in Kaduna North, Nigeria.

Theoretical Framework

This study is based on the constructivist learning theory of Ausubel P. David, an American psychologist who proposed a learning theory in 1963 called the subsumption theory. According to Ausubel's subsumption theory, students absorb new information by connecting it to existing concepts and ideas they have already acquired. This means that meaningful learning can only occur when what is learned is related to what is already known and exists in the student's mind.

Constructivism is a theory based on mental construction. It suggests that students learn by linking new information with what they already know and that people construct their understanding and knowledge of the world through experiences and reflecting on them. Constructivist theories hold that knowledge is actively constructed in the mind of the learner and that the teacher's primary role is to create an appropriate learning environment in which students' experiences are authentic presentations of real practices in applied settings. In constructivism, the learner should be the primary focus of the learning process. Learners must actively develop their knowledge, take responsibility for their learning outcomes, and use their creativity and liveliness to stand alone in their cognitive lives. A central point in constructivism is that learning is always a unique product "constructed" as each learner combines new information with existing knowledge and experiences. Individuals have learned when they have constructed new interpretations of the social, cultural, physical and intellectual environment in which they live. The basic principle of the constructivism theory is applied in this study, in which learners can create meaning and appropriate learning experiences of geometry through the Know-Want-The strategy. This is aimed at helping them in the learning experience, improving their academic performance and boosting their performance in geometry in line with the theoretical stipulations of constructivist principles.

Research Questions

The following research questions were used to guide the conduct of this research;

What is the difference in the mean performance score of the students taught geometry by the KWL strategy and those taught with the conventional method?

What is the difference between the mean performance scores of male and female students taught geometry by the KWL strategy?

Null Hypotheses

The following null hypotheses are formulated to guide the researcher in the analysis of the study and will be tested at a $P \leq 0.05$ level of significance.

HO_1. There is no significant difference in the mean performance score of the students taught geometry by the Know-Want-Learn (KWL) strategy and students taught by a conventional method.

HO_2. There is no significant difference between the mean performance scores of male and female students taught geometry by the Know-Want-Learn (KWL) strategy.

METHODOLOGY

Research Design

In this study, a quasi-experimental design was employed, utilizing a pre-test and post-test non-randomized control group approach. The research involved the formation of two groups: the experimental group (EG), which was exposed to the Know-Want-Learn (KWL) strategy, and the control group (CG), which received instruction through the conventional lecture method. To establish equivalence between the two groups before treatment, a pre-test (denoted as O1) was administered. The results of this pre-test were crucial in assessing baseline performance levels. After a six-week intervention period, a post-test (O2) was administered to evaluate the effectiveness of the KWL strategy on the academic performance of students in Geometry. Figure 3.1 illustrates the research design.

$$EG \rightarrow O_1 \rightarrow X_1 \rightarrow O_2$$

$$CG \rightarrow O_1 \rightarrow X_0 \rightarrow O_2$$

Figure 1. Schematic Illustration of the Research Design

Population and Sample

The parent population for this study encompassed all upper-basic students in the Kaduna North Local Government Area of Kaduna State. Specifically, the accessible population consisted of all upper-basic eight (8) students from the Kaduna North local government, which includes a total of sixteen (16) public upper-basic secondary schools with an overall enrollment of six thousand three hundred (6,300) students. Among these schools, eight (8) are coeducational institutions, while the remaining eight (8) consist of single-gender schools, comprising both boys' and girls' schools. The sample for this study included 98 students from upper-basic eight (8) secondary schools who voluntarily agreed to participate. This group was selected based on their stability within the school system, ensuring a reliable cohort for data collection. Each participant consented to the use of a pen-and-paper approach, with explicit measures taken to ensure the confidentiality of their personal information. Students were informed that their data would be utilized solely for research purposes and that participation would not influence their academic grades. They were also assured that there would be no repercussions for opting out of the study. Furthermore, written consent was obtained from and approved by the principal of each participating school, ensuring ethical compliance in the research process.

Instrumentation

The data collection method used in this study was the Geometry Performance Test (GPT), which was constructed by the researchers. The test consisted of 28 multiple-choice objective questions, with four options each, drawn from the topics that were taught to the students. There are several reasons why it is justified to use multiple-choice objective questions in tests. Initially, these assessments enable a thorough evaluation of students' comprehension of various subjects in a short period, ensuring an efficient assessment of a wide range of content (Haladyna & Rodriguez, 2013). Multiple-choice questions are considered objective as they remove scorer bias and guarantee that all students are assessed using the same criteria (Brookhart, 2010). In addition, they are perfect for evaluating factual knowledge and specific skills, which are vital aspects in subjects such as mathematics, in which accuracy and precision are essential (Brame, 2013). Moreover, meticulously crafted multiple-choice questions can evaluate advanced thinking skills like analysis and application, challenging students to distinguish between related concepts or apply principles in new situations (Haladyna & Rodriguez, 2013). This structure guarantees a dependable and just evaluation of the student's understanding and mental capacities. These topics included quadrilaterals (connections between quadrilaterals), angles between lines, angles in triangles, angles in quadrilaterals, angles in polygons, and Pythagoras' rule. Both the experimental and control groups were taught these topics, but the experimental group received the treatment using the Know-Want-Learn strategy, while the control group was taught using a conventional lecture method. Students were given 1 hour and 30 minutes to complete the test and were required to choose the correct answer from the four options provided for each question. The GPT underwent validation to ensure its reliability and validity. After validity checks, some items were restructured and amended by the researchers to enhance their quality. To ensure that the Geometry Performance Test (GPT) accurately measures students' understanding of geometry, we carefully matched the test questions with the educational goals and subjects covered in the curriculum. Content validity is crucial in making sure that the test thoroughly covers the material it aims to assess, ensuring that each question genuinely represents important geometry concepts. First, we thoroughly reviewed the geometry curriculum to ensure that the test questions closely aligned with the subjects taught during the instructional period. Each multiple-choice question was drawn from fundamental geometry areas such as shapes, lines, angles, and spatial relationships. Next, we sought the input of experienced math teachers and subject matter experts to evaluate the test questions. Their valuable feedback helped ensure that the questions aligned with the curriculum and were appropriately challenging for students at their grade level. Furthermore, we aimed to represent different subjects and levels of complexity fairly throughout the test. This careful planning ensured that all areas of geometry were equally represented, providing an accurate assessment of the range of knowledge and skills students needed to learn. By following these procedures, we achieved high content validity for the GPT, effectively covering the key components of the geometry curriculum. Emphasizing content validity is crucial in achievement tests to ensure that the assessment accurately reflects students' understanding and skills in the subject area. The first 40 questions of the Geometry Proficiency Test (GPT) were examined to assess the questions' quality and the test's reliability. The test centred on two primary factors: difficulty and discrimination indices.

Measure of Difficulty: This metric assesses the degree of simplicity or difficulty of a test question, usually depicted as the proportion of students who solved it accurately. It is commonly agreed upon that an optimal difficulty rating falls between 0.30 and 0.70. This range shows that the item is at an appropriate level of difficulty for many students, enabling a beneficial assessment of their comprehension (Angoff, 1971).

Index of Differentiation: This index shows how well an item can distinguish between high-performing students and low-performing students. It is advised that the discrimination index should be higher than 0.20 as a benchmark. Items with a discrimination index lower than this level may not accurately distinguish between students who understand the material and those who do not (Ebel & Frisbie, 1991). During our examination, it was discovered that only 28 items out of the total 40 items met the suggested standards for difficulty and discrimination indices. Specifically, items that were considered suitable for the final test fell within the optimal difficulty range of 0.30 to 0.70. Similarly, items with discrimination indices greater than 0.20 were deemed successful in evaluating student performance. The Geometry Proficiency Test (GPT) consists of 28 questions, each worth a maximum of one point, making the total possible score on the test 28. Each question holds equal worth, amounting to one point each. Therefore, students can accumulate a maximum of 28 points. We used the Pearson correlation coefficient to measure the reliability of the test-retest by evaluating the strength and direction of the linear relationship between two sets of data. The researchers evaluated the test-retest reliability by administering the 28-item GPT to the same students twice and comparing their scores from both instances. An 0.86 reliability coefficient indicates that the geometry knowledge test is dependable over time and trustworthy for assessing students' understanding of geometry.

Procedure for data collection

Data Analysis

A group of experienced secondary school mathematics educators were chosen to join as research assistants and were instructed on implementing the Know-Want-Learn (KWL) method for teaching geometry. The training program spanned three weeks and consisted of interactive sessions, practice, and observations of the research assistants' work. Two research assistants were selected to apply the KWL strategy in the study due to their comprehensive knowledge of it. This selection aimed to minimize variation caused by varying levels of teacher effectiveness, to control for a possible extraneous variable. Randomly allocated students were assigned to either the experimental or control group to better control extraneous variables. Random assignment ensured that any group variations, like previous knowledge or skill level, were distributed equally. Both groups were educated under uniform conditions in terms of content, duration, and structure of lessons, with the only variation being the instructional approach utilized. The KWL strategy was used for teaching the experimental group, while the control group was taught using traditional lecture methods.

Before the intervention phase, both groups were administered a Geometry Performance Test (GPT) as an initial assessment. This initial evaluation was essential in determining the starting point equality among the groups so that any differences seen in the post-test could be linked to the intervention instead of existing knowledge or abilities. The initial disparities were accounted for by using the pre-test results in the analysis of covariance (ANCOVA) to control for potential confounding variables influencing the outcome. After the pre-test, both groups received six weeks of geometry instruction during the treatment phase of the study. The experimental group maintained KWL strategy instruction, while the control group stuck with traditional teaching methods. Upon completion of the treatment period, both sets of participants underwent a reevaluation through the Geometry Performance Test (GPT), with scores assessed based on a standardized grading system. One mark each was given for right answers, up to a total of 28 marks for the whole test. The average grades of students in both groups were compared using an independent samples t-test, with the hypotheses being tested at a significance level of $p \leq 0.05$.

RESULTS

Research Question One

Table 1. Mean Performance Scores of the Experimental and Control Group.

Group	N	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Mean Difference (Post-test)
Experimental	50	11.90	3.086	23.52	3.177	8.833
Control	48	10.08	3.853	14.69	2.002	
Total	98					

Table 1 presents the mean performance scores of the experimental group and control group. The experimental group (N=50) had a pre-test mean of 11.90 (S.D = 3.086) and a post-test mean of 23.52 (S.D = 3.177). Also, the control group (N=48) had a pre-test mean of 10.08 (S.D = 3.853) and a post-test mean of 14.69 (S.D = 2.002). The mean difference in post-test scores between the two groups is 8.833.

Null Hypothesis One

HO_1: There is no significant difference in the mean performance scores of the students taught geometry by the KWL strategy and students taught by the conventional method.

The results of the Univariate Analysis of Variance (ANCOVA) were conducted to compare the performance scores of students taught geometry using the Know-Want-Learn (KWL) strategy against those taught through conventional methods. The analysis included two groups: the experimental group (N = 50), which received instruction using the KWL strategy, and the control group (N = 48), which followed conventional lecture methods. Descriptive statistics indicated that the experimental group had a mean performance score of 23.52 (S.D. = 3.177), while the control group achieved a mean score of 14.69 (S.D. = 2.002). The overall mean performance score across all participants was 19.19 (S.D. = 5.171). Levene's Test of Equality of Error Variances revealed a significant difference in variances between the groups ($F(1, 96) = 11.705$, $p = .001$). This violation of the homogeneity of variance assumption suggests that the error variance of the dependent variable, performance, was not equal across groups.

Table 2. Results of ANCOVA for Performance Scores by Group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1932.473[a]	2	966.236	138.902	.000	.745
Intercept	2715.783	1	2715.783	390.409	.000	.804
PRE_TEST	21.949	1	21.949	3.155	.079	.032
GROUPS	1687.013	1	1687.013	242.518	.000	.719
Error	660.844	95	6.956			
Total	38697.000	98				
Corrected Total	2593.316	97				

The ANCOVA results, summarized in Table 2, demonstrated a statistically significant corrected model ($F(2, 95) = 138.902$, $p < .001$), which accounted for approximately 74.5% of the variance in performance scores (Partial Eta Squared = .745). The factor representing group differences (GROUPS) was also statistically significant ($F(1, 95) = 242.518$, $p < .001$), indicating a notable difference in performance between the experimental and control groups, with a large effect size (Partial Eta Squared = .719). Conversely, the covariate, pre-test scores ($F(1, 95) = 3.155$, $p = .079$), did not significantly influence post-test performance after controlling for group differences. The estimated marginal means further elucidate the findings: the experimental group had an estimated mean performance score of 23.398 (S.E. = .379), with a 95% confidence interval ranging from 22.645 to 24.151. In contrast, the control group's estimated mean was 14.815 (S.E. = .387), with a confidence interval between 14.046 and 15.584. The ANCOVA results indicate that the KWL strategy significantly enhances student performance in geometry compared to traditional teaching methods. The substantial difference in mean scores, combined with the effect size, supports the effectiveness of the KWL strategy in improving students' understanding of geometry concepts.

Research Question

Table 3. Mean Performance Scores of Male and Female Students Taught by KWL Strategy

Group	N	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Mean Difference (Post-test)
Male	55	10.78	3.900	19.40	5.304	.470
Female	43	11.30	3.151	18.93	5.045	

Table 3 presents the mean performance scores of male and female students taught geometry by the KWL strategy. Male (N=55) had a pre-test mean of 10.78 (S.D = 3.900) and a post-test mean of 19.40 (S.D = 5.304). Also, females (N=43) had a pre-test mean of 11.30 (S.D = 3.151) and a post-test mean of 18.93 (S.D = 5.045). The mean difference in post-test scores between the two groups is 0.470

Null Hypothesis Two

H0$_2$: There is no significant difference between the mean scores of male and female students when taught using the KWL strategy.

The Univariate Analysis of Variance (ANOVA) was conducted to investigate the impact of gender on performance scores among secondary school students. The analysis included a total of 98 participants, consisting of 43 females and 55 males. Descriptive statistics revealed that the mean performance score for female students was 18.93 (standard deviation = 5.045), whereas male students achieved a mean score of 19.40 (standard deviation = 5.304). The overall mean performance score across all participants was 19.19 (standard deviation = 5.171). To assess the assumption of homogeneity of variance between the gender groups, Levene's Test was performed. The result was non-significant ($F(1, 96) = 0.441$, $p = .508$), indicating that the variances were equal across groups.

Table 4. Results of ANCOVA for Performance Scores by Gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	257.377[a]	2	128.689	5.234	.007	.099
Intercept	1848.864	1	1848.864	75.191	.000	.442
PRE_TEST	252.051	1	252.051	10.251	.002	.097
GENDER	11.918	1	11.918	.485	.488	.005
Error	2335.939	95	24.589			
Total	38697.000	98				
Corrected Total	2593.316	97				

The results of the ANOVA analysis indicated that the overall corrected model was statistically significant ($F(2, 95) = 5.234$, $p = .007$), explaining approximately 9.9% of the variance in performance scores (Partial Eta Squared = .099). The intercept was significant ($F(1, 95) = 75.191$, $p < .001$), indicating a strong relationship between the intercept and performance scores. Furthermore, the covariate of pre-test scores significantly influenced performance (F(1, 95) = 10.251, p = .002, Partial Eta Squared = .097), suggesting that prior knowledge or skills were important factors in predicting performance outcomes. However, the main effect of gender was not statistically significant (F(1, 95) = 0.485, p = .488, Partial Eta Squared = .005), indicating that there was no significant difference in performance scores between male and female students. While pre-test scores had a significant effect on performance, the analysis found no significant influence of gender on the student's performance in geometry. These findings imply that teaching strategies may need to address factors beyond gender to enhance student performance effectively.

Discussion of the Results

The results confirm that the KWL strategy is successful in enhancing students' geometry skills. In comparison to the control group of 48 participants, who had a mean score of 14.69 (standard deviation = 2.002), the experimental group of 50 participants demonstrated notable progress in their post-test outcomes, yielding a mean score of 23.52 (standard deviation = 3.177). This resulted in a mean increase of 8.833, indicating a substantial enhancement in the experimental group. Previous studies have also demonstrated the efficacy of the KWL strategy in enhancing understanding and retention of mathematical concepts, as evidenced by these findings (Al Barakati, 2008; Aseeri, 2020). The results of the Univariate Analysis of Covariance (ANCOVA) indicate significant findings, showing a strong group effect (F(1, 95) = 242.518, p < .001) with a large effect size (Partial Eta Squared = .719). This suggests that the KWL strategy had a significant impact on performance scores, demonstrating its effectiveness compared to the conventional method. Therefore, we reject the null hypothesis (H01), which suggests no significant difference in the mean performance scores of students taught geometry using the KWL strategy versus those taught using the conventional lecture method.

The results of the pre-test indicated that the experimental group's mean score was 11.90 (SD = 3.086), whereas the control group's mean score was 10.08 (SD = 3.853). Even though the experimental group initially had a slightly better baseline knowledge, the ANCOVA findings showed that the pre-test scores did not have a significant effect on the post-test results once group differences were taken into consideration (F(1, 95) = 3.155, p = .079). This indicates that while previous knowledge plays a role, the KWL strategy effectively helps bridge knowledge gaps and enhances student engagement with the material. This research found that there was no notable variance in performance scores of male students (mean post-test = 19.40, SD = 5.304) and female students (mean post-test = 18.93, SD = 5.045) (F(1, 95) = 0.485, p = .488). This finding reinforces prior studies suggesting that the implementation of creative teaching techniques can lessen disparities in academic performance between males and females (Thomas & Swamy, 2014). Hence, the null hypothesis (H02) stating that there is no significant difference between the mean scores of male and female students instructed with the KWL strategy is supported. Moreover, the important role of pre-test scores as a covariate (F(1, 95) = 10.251, p = .002) underscores the significance of previous knowledge in forecasting performance results. This highlights the importance of educators assessing students' current comprehension levels before implementing instructional approaches, as utilizing students' prior knowledge enhances their capacity to learn new information.

This study validates that the KWL strategy is successful in enhancing students' comprehension of geometry. It also emphasizes how crucial prior knowledge is in influencing performance results. The research shows compelling proof of the KWL strategy's effectiveness in math education and recommends its broader implementation. Future studies need to investigate how effective the KWL strategy is in improving student learning over an extended period, as well as its applicability across various mathematical subjects and student demographics.

Conclusion

The study examined the effectiveness of the Know-Want-Learn (KWL) strategy on students' performance in geometry, comparing it to the conventional lecture methods. The results showed that students taught using the KWL strategy demonstrated a significant improvement in their understanding of geometric concepts, as indicated by their post-test scores. Specifically, the experimental group achieved a mean post-test score of 23.52, which was significantly higher than the control group's mean score of 14.69. This improvement can be attributed to the KWL strategy's structured approach, which actively engages students in the learning process by prompting them to identify what they know, what they want to learn, and what they have learned. Additionally, the KWL strategy was equally effective for both male and female students, with no significant difference in performance based on gender. This finding underscores the strategy's inclusivity and adaptability, making it a suitable teaching method for diverse classroom settings. The results are consistent with previous research that emphasizes the effectiveness of student-centred teaching strategies in improving academic performance, thereby highlighting the importance of innovative instructional methods in mathematics education. Based on these findings, the KWL strategy emerges as a promising approach to teaching geometry, with the potential to enhance educational outcomes in upper-basic schools.

Recommendations

Based on the conclusions drawn from this research, the following recommendations are proposed to enhance mathematics education in upper-basic schools:

1. Adoption of KWL Strategy: Mathematics educators should incorporate the KWL strategy into their instructional practices. This approach can foster a more interactive learning environment, encouraging students to take an active role in their education and promoting a deeper understanding of geometric concepts.

2. Professional Development for Educators: Schools and educational authorities should invest in professional development programs that train educators on the effective implementation of the KWL strategy. Such training can equip teachers with the skills needed to facilitate student engagement and effectively assess learning outcomes.

3. Integration Across Subjects: While this study focused on geometry, the KWL strategy could be adapted for use in other subjects, promoting interdisciplinary learning. Educators should explore the applicability of the KWL approach in various mathematical concepts and beyond, fostering a holistic educational experience.

4. Curriculum Development: Curriculum designers should consider integrating the KWL strategy into the mathematics curriculum for upper-basic schools. By embedding this instructional method into the curriculum, schools can create a standardized approach that enhances students' learning experiences.

5. Research on Long-term Effects: Further research is needed to explore the long-term effects of the KWL strategy on students' mathematics performance and attitudes towards the subject. Longitudinal studies could provide insights into the sustained impact of this teaching method.

6. Inclusive Practices: Schools should implement the KWL strategy in both co-educational and single-sex environments to ensure that all students benefit from this effective teaching method. Promoting inclusivity in education can help address varying learning needs and styles.

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