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# CONSTRUCTION OF STUDENTS' MOTIVATIONAL ATTITUDE SCALE ON GEOMETRY

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## Abstract

This study developed and validated the Student's Motivational Attitude Scale on Geometry (SMASG), a psychometric instrument designed to measure secondary school students' attitudes toward geometry. Employing an instrumentation research design, a 40-item questionnaire (featuring a set of positively and negatively worded statements on a four-point scale) was trial tested on 40 Senior Secondary School Three (SSS3) students. Data was collected from a sample of 197 from a population of 1082 SSS3 students in schools within Gboko town. Factor analysis was used to assess scale reliability and explore the underlying factor structure. The analysis yielded a high Cronbach's alpha reliability coefficient of 0.84. Furthermore, exploratory factor analysis using Varimax rotation revealed that students' attitudes are not unidimensional but are characterized by a four-factor structure, identifying four distinct and meaningful psychological constructs that shape students' perceptions of geometry. This valid and reliable scale provides educators and researchers with a robust tool for assessing motivational attitudes in the context of geometry education. The study concludes that a student's relationship with geometry is not one-dimensional. It is a complex interplay of how much they enjoy it, how anxious it makes them, how useful they think it is, and whether they believe it's relevant to their life. Recommendations were made based on the findings of the study.

**Keywords: Geometry, Instrument Validation, Factor Analysis, Student Motivation**.

## Introduction

Mathematics, and geometry in particular, has long served as a cornerstone of human intellectual achievement, providing a rigorous framework for modeling the physical world and abstract thinking. Its role in education is consequently paramount, making the accurate assessment of mathematical proficiency a critical endeavor for educators and researchers alike (National Council of Teachers of Mathematics [NCTM], 2014). However, the true value of any educational assessment is contingent upon its reliability (the consistency and stability of its scores across different administrations, raters, or item samples (American Educational Research Association [AERA] et al., 2014). Establishing this reliability is not merely a statistical exercise; it is a fundamental requirement for ensuring that test results are a trustworthy reflection of a student's mathematical understanding rather than a product of measurement error or chance. To this end, factor analysis emerges as an indispensable psychometric tool. It allows researchers to probe the internal architecture of a test, moving beyond a single composite score to investigate the underlying constructs or factors that the items collectively measure (Emaikwu, 2021). In the context of a geometry assessment, factor analysis can be employed to answer essential questions: Does the test measure a unitary "geometry ability," or are there distinct latent traits, such as spatial visualization, deductive reasoning, and theorem application, at play? By analyzing the patterns of covariance among test items, this methodology provides an empirical basis for evaluating construct validity and refining the instrument to ensure it reliably captures the multifaceted nature of geometric knowledge (Kline, 2016). Thus, the application of factor analysis is not just a statistical validation but a geometric mapping of the cognitive terrain itself, ensuring that the assessment tool is a precise and reliable measure of the intended mathematical constructs.

This study is anchored on the highly relevant and robust theory for measuring learner motivation in geometry known as Self-Determination Theory (SDT), formally developed by psychologists Edward Deci and Richard Ryan in the mid-1980s. This theory posits that optimal motivation and engagement are fostered when an individual's three innate psychological needs, autonomy (the need for choice and control), competence (the need to feel effective), and relatedness (the need to feel connected to others) are supported. SDT is exceptionally relevant to the study of geometry because the subject's often abstract and challenging nature, with its demanding proofs and spatial reasoning, can easily lead to frustration and motivation. The theory provides a framework to measure how teaching practices (such as offering meaningful choices in problems, scaffolding tasks to ensure success, and facilitating collaborative learning) directly impact these core needs, thereby predicting a student's shift from extrinsic compliance to the intrinsic interest and persistent engagement required to master complex geometrical concepts.

Constructing a valid and reliable instrument to measure attitude, such as an attitude scale towards mathematics or geometry, is a meticulous process that requires a rigorous methodological approach. The construction of an attitude scale is a multi-stage psychometric process that begins with clear conceptualization and item generation based on a precise definition of the construct and its dimensions, often informed by a literature review or theoretical framework (DeVellis, 2017). This is followed by content validation, where a panel of expert judges evaluates the item pool for clarity, relevance, and representativeness to ensure the scale possesses content validity. This crucial phase involves factor analysis (Exploratory Factor Analysis (EFA) to identify the underlying factor structure and Confirmatory Factor Analysis (CFA) to test how well that structure fits the data, thus establishing construct validity (Kline, 2016; Taherdoost, 2016). Finally, the scale's reliability is computed, typically using Cronbach's alpha to measure internal consistency, with a coefficient of 0.70 or higher considered acceptable for research purposes (Tavakol & Dennick, 2011). This method ensures the final attitude scale is both a reliable (consistent) and valid (accurate) measure of the intended psychological construct.

Aminu and Abdullahi (2023) developed the Geometry Attitude Questionnaire (GPT), which was validated by senior lecturers in the science education department at Ahmadu Bello University, Zaria, Shehu Shagari College of Education, Sokoto, and Mathematics Teachers in Sokoto State. The Instrument was developed to assist researchers carrying out studies at Junior Secondary School (JSS), Senior Secondary (SS) and Tertiary institutions across the country and some other African countries. GAQ is a structured modified Likert scale with four options of Strongly Disagree [SD (1)]; Disagree [D (2)]; Agree [A (3)]; and Strongly Agree [SA (4)]. Each item carries 1 mark. The GAQ consists of all Geometry content and methods of teaching (Students Team Achievement Division STAD and INQUIRY) of JSS. Difficult and simple areas of the JSS 3 Mathematics curriculum of NERDC 2013 were used, and Basic Education Certificate Examination (BECE) past question papers were used to form GAQ. Reliability was carried out with two schools in Sokoto using the test-retest method, and Cronbach alpha was used to analyze the data, which yielded a reliability coefficient of 0.72, which shows that the instrument is reliable and can be used to conduct an experimental study, particularly at the JSS 3 level in Nigeria and some other countries.

Cabig and Cubi (2025) researched Attitudes of Students towards Learning Geometry: A Mixed Method Study, aimed to describe the lived experiences of mathematics teacher education students in a local college on their geometry attitudes. This study engaged a mixed-method design, utilizing a parallel convergent approach. The participants of the study were the mathematics education students from the first year to the third year. There were 212 students who were randomly selected for the quantitative study and 14 for the qualitative. Based on the results of the study, it was concluded that the status of students' attitude towards learning geometry was high. The results from the quantitative and qualitative converged when they were being corroborated. The results confirm that mathematics major students appreciate geometry for its practical applications in daily life and future careers. Their genuine interest in the subject fosters confidence, leading to higher academic achievements. Moreover, the students find enjoyment in exploring the diverse and relevant topics within geometry, further enhancing their learning experience. The findings suggest that students should develop a strong grasp of geometry and cultivate a keen interest in learning the subject. Students may regularly practice geometric problems, use extra learning materials like books and online resources, solve real-life geometry problems to see its practical uses, and stay curious and persistent when facing difficulties. This approach will help them build confidence and develop a positive attitude towards geometry

## Research questions

The following research questions guided the study;

1. What is the reliability coefficient of the attitude scale items?
2. What are the factors underlying all the items?

## Methodology

The study employed an instrumentation research design. This research design is used for the development of tests, questionnaires, scales, inventories, or other measuring instruments. It focuses on ensuring that the instrument is valid, reliable, objective, and suitable for measuring a specific variable. This design is suitable because the major purpose of the study is to develop, validate, and standardize a measuring instrument that can assess students' motivational attitudes toward geometry.

A 40-item questionnaire (featuring a set of positively and negatively worded statements on a four-point scale) was trial-tested on 40 Senior Secondary School Three (SSS3) students. This valid and reliable scale provides educators and researchers with a robust tool for assessing motivational attitudes in the context of geometry education.

This study used instrumentation research as its methodological foundation. In research, a measurement tool (such as a checklist, test, or questionnaire) is commonly referred to as an instrument. However, it is important to distinguish between the terms instrument and instrumentation. While an instrument is the physical device used to gather data, instrumentation refers to the comprehensive process or procedure of designing, developing, validating, and applying that instrument in the context of a study (Creswell & Creswell, 2018). This process ensures that the tool accurately measures the intended constructs and yields reliable and valid results. By focusing on instrumentation, this study emphasizes the importance of methodological rigor in the creation and use of data collection tools.

The study utilized the 40-item Student's Motivational Attitude Scale on Geometry (SMASG), which was designed on a four-point scale, with four options of Strongly Disagree (SD); Disagree (D); Agree (A); Strongly Agree (SA). The questionnaire was trial tested on forty (40) Senior Secondary School Three (SSS3) students, who did not form part of the population of the study, to determine the scale's reliability. This was done after a validation process by two Measurement and Evaluation experts and an experienced Mathematics teacher at the secondary school level. Having undergone the necessary corrections identified during the validation, the final items were administered to 197 SSS3 Students out of 1802 students in Gboko town using a simple random sampling. The sample size was determined using Taro Yamane's formula (Emaikwu, 2021). The data were then analyzed using the SPSS software package to examine its factor structure. Factor analysis was used to assess scale reliability and explore the underlying factor structure. The analysis yielded an alpha reliability coefficient of 0.84. Furthermore, exploratory factor analysis using Varimax rotation was used to determine whether students' attitudes are not unidimensional and meaningful psychological constructs that shape students' perceptions of geometry.

## Results and Discussion

**Research question one:** What is the reliability coefficient of the attitude scale items?

**Table 1: Showing the reliability coefficient of the attitude scale**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .846 | .849 | 40 |

The analysis gives a reliability coefficient of 0.85, which shows that the items are very reliable. That is, 85% is the estimation resulting from the true variance, while the remaining 16% is due to error variance (Emaikwu, 2021).

**Research Question Two:** What are the factors underlying all the items?

**Table 2: Showing the factor loadings underlying the items**

| | | **Components** | | | |
|---|---|---|---|---|---|
| S/No | Item | 1 | 2 | 3 | 4 |
| 1 | I enjoy solving geometry problems | .552 | | .275 | .049 |
| 2 | Geometry is one of my favourite topics in mathematics | .659 | -.071 | -.186 | -.150 |
| **3** | I feel anxious whenever geometry is being taught. | -.206 | .381 | -.147 | |
| 4 | Geometry lessons are interesting and engaging. | .489 | .033 | .164 | -.150 |
| 5 | I am confident whenever I face geometry questions. | .602 | | .062 | .107 |
| **6** | I feel discouraged when my answers in geometry are wrong. | .034 | .159 | -.450 | .035 |
| 7 | I find joy in drawing and interpreting geometric figures. | .513 | | | .150 |
| **8** | Geometry makes me nervous during examinations. | -.094 | .458 | -.150 | .325 |
| 9 | I feel excited when working on geometry homework. | .383 | | .129 | .453 |
| **10** | Geometry is a subject I would prefer to avoid. | .106 | .518 | | -.055 |
| 11 | Geometry improves my self-confidence in mathematics. | .571 | .113 | -.054 | .459 |
| **12** | I feel frustrated when solving geometry problems. | .092 | .444 | .031 | .233 |

| | | | | | |
|---|---|---|---|---|---|
| 13 | Geometry makes mathematics enjoyable for me. | .460 | .075 | .230 | .454 |
| **14** | I easily lose interest when the teacher introduces the theory of tangent to a circle. | .077 | .509 | -.040 | .123 |
| 15 | I like participating in class discussions about geometry. | .542 | | .210 | -.081 |
| 16 | I do not see geometry problems as overwhelming | .359 | -.176 | .150 | .184 |
| **17** | I skip geometry assignments whenever I can. | -.050 | .601 | .104 | -.157 |
| 18 | I take extra time to practice geometry outside school hours. | .593 | .048 | | |
| 19 | I make active contributions during geometry lessons | .473 | .032 | .393 | |
| **20** | I usually copy geometry homework solutions of my classmates without doing it myself. | | .603 | | |
| 21 | I try to apply geometry in solving real-life problems. | .373 | -.051 | .290 | .262 |
| **22** | I avoid geometry questions in tests if there is an option. | | .618 | -.202 | .310 |
| 23 | I consult textbooks or online resources to improve in geometry. | .589 | -.096 | .070 | |
| **24** | I make less effort on geometry compared to other Mathematics topics. | | .390 | -.088 | -.170 |
| 25 | I take time to revise geometry problems before examinations. | .462 | .037 | | .114 |
| 26 | I willingly volunteer to solve geometry problems on the board. | .496 | | .184 | .070 |
| **27** | I neglect geometry revision because I think it is too hard. | .121 | .606 | -.052 | .051 |
| 28 | Geometry helps me to develop logical thinking. | .359 | -.050 | .381 | .066 |
| **29** | Geometry is not useful in everyday life. | -.105 | .527 | .203 | -.114 |
| 30 | Understanding geometry is important for success in science subjects. | .307 | .041 | .490 | -.409 |
| **31** | Geometry is a waste of time in the school curriculum. | -.144 | .451 | .327 | -.445 |

| | | | | | |
|---|---|---|---|---|---|
| 32 | Knowledge of geometry is essential for careers in science and technology. | .241 | .054 | .629 | -.121 |
| **33** | Geometry is too abstract to have any practical value. | -.089 | .320 | | -.122 |
| **34** | Geometry is only for very exceptional students. | -.131 | .445 | -.035 | -.434 |
| 35 | Geometry is important for understanding shapes and structures in real life. | .113 | | .656 | .097 |
| 36 | Without geometry, mathematics is incomplete. | .404 | -.047 | .285 | -.300 |
| **37** | Geometry is too difficult for me to understand. | .143 | .478 | -.086 | -.447 |
| 38 | Geometry provides a foundation for advanced mathematical topics. | .326 | -.041 | .497 | -.079 |
| 39 | Geometry enhances my ability to reason systematically. | | .080 | .687 | .354 |
| **40** | Geometry has no relevance to my future career. | -.230 | .467 | .091 | .110 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations.

The researcher likely administered a questionnaire with many items (statements) about geometry. The goal of this analysis was to reduce the number of variables **and** discover the underlying themes or "factors" that the questions are measuring. The four columns (Component 1, 2, 3, 4) represent these discovered factors.

Based on the patterns of high-loading questions, we can name and interpret each factor.
Component 1: Positive Engagement and Self-Efficacy in Geometry
This is the clearest and strongest factor, defined by many high loadings. It measures a positive affective and behavioral disposition towards geometry. It combines enjoyment, interest, confidence, and active effort.

Items with high loadings > 0.5
"Geometry is one of my favorite topics..." (0.659)
"I am confident whenever I face geometry questions." (0.602)
"I take extra time to practice geometry..." (0.593)
"I consult textbooks or online resources..." (0.589)
"I enjoy solving geometry problems" (0.522)
"I like participating in class discussions..." (0.542)

Interpretation: This factor represents the ideal student attitude. Students with a high score on this factor don't just feel good about geometry (confidence, enjoyment), they also act on it (practice, consult resources, participate). It's a blend of affective (emotional) and behavioural (effort) engagement.

Component 2: Geometry Anxiety and Avoidance Behaviour

This factor captures the negative emotional and behavioural response to geometry. This component measures feelings of anxiety, frustration, and discouragement related to geometry, leading to active avoidance.

Items with high loadings > 0.5

"I neglect geometry revision because I think it is too hard." (0.606)

"I skip geometry assignments whenever I can." (0.601)

"I usually copy geometry homework solutions..." (0.603)

"I avoid geometry questions in tests if there is an option." (0.618)

"Geometry is a subject I would prefer to avoid." (0.518)

Interpretation: This is the opposite of Component 1. It is characterized by negative affect (anxiety, frustration), which directly translates into maladaptive behaviours (skipping, copying, avoiding). The presence of both emotion and action here mirrors the structure of Component 1, making it a coherent "negative engagement" factor.

Component 3: Recognition of Geometry's Utility and Value

This factor is focused on the perceived usefulness and importance of geometry, both academically and in real life. The belief that geometry is practical, relevant, and important for future success.

Items with high loadings > 0.5

"Geometry enhances my ability to reason systematically." (0.687)

"Geometry is important for understanding shapes and structures in real life." (0.656)

"Knowledge of geometry is essential for careers in science and technology." (0.629)

"Geometry provides a foundation for advanced mathematical topics." (0.497)

Interpretation: This is a cognitive evaluation of geometry's value. It's separate from liking it (Component 1) or being anxious about it (Component 2). A student could find geometry difficult and frustrating (high on Component 2) but still believe it is important (high on Component 3).

Component 4: Negative Beliefs about Geometry's Relevance and Difficulty

This factor is defined by a specific set of beliefs that geometry is irrelevant, too difficult, and a waste of time. This measures a dismissive and pessimistic mindset regarding geometry's practicality and accessibility.

Items with high loadings, noting the negative loadings

"Geometry has no relevance to my future career." (0.467)

"Geometry is not useful in everyday life." (0.527)

"Geometry is a waste of time in the school curriculum." (0.445, with a cross-loading)

"Geometry is too difficult for me to understand." (-0.447) The negative sign here suggests this item is worded in a way that, when disagreed with, aligns with the other negative beliefs.
"I feel discouraged when my answers in geometry are wrong." (-0.450) [Similar note on the negative loading.]
Interpretation: This factor is subtly different from Component 2. While Component 2 is about emotional and behavioural avoidance, Component 4 is about intellectual justification for that avoidance. It represents the belief system that underpins the avoidance: "I avoid it because it's useless and too hard."

## Conclusions and Recommendations

The factor analysis successfully delineated four distinct psychological constructs underlying student attitudes toward geometry, revealing a multifaceted relationship with the subject. These dimensions range from Positive Engagement and Self-Efficacy, which encapsulate enjoyment, confidence, and proactive learning behaviors, to their direct counterpart, Anxiety and Avoidance, characterized by negative emotions and evasive actions. The analysis further separates students' cognitive appraisals, identifying one factor centered on the Perceived Utility of geometry for academic and real-world applications, and another defined by a belief in its Perceived Irrelevance and Difficulty, which provides an intellectual justification for disengagement. Together, these factors provide a comprehensive framework for understanding how students simultaneously feel, act, and think about geometry. The study reveals that a student's relationship with geometry is not one-dimensional. It is a complex interplay of how much they enjoy it, how anxious it makes them, how useful they think it is, and whether they believe it's relevant to their life. Based on the findings of the study (the successful identification of four distinct attitudinal factors), it is recommended that:

(i) Future research utilizes the computed factor scores as composite variables in subsequent analyses.

(ii) This approach will allow for a more nuanced and powerful investigation into the drivers of student success and engagement in geometry.

(iii) Specifically, these scores can be employed as either independent variables to test predictive models (for instance, examining how Positive Engagement and Geometry Anxiety directly influence academic achievement) or as dependent variables to assess the impact of educational interventions, such as whether a new curriculum significantly improves students' Perceived Utility of geometry.

(iv) By moving beyond individual survey items to these robust, validated constructs, researchers can generate higher-level insights with greater explanatory power, ultimately informing the development of targeted strategies to improve geometry education and student outcomes.

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