

## Relationship between laboratory method of teaching, students' attitude and gender on students' performance in geometry

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**Abstract:** The relationship between the laboratory method of instruction, students' attitudes toward geometry, and gender on geometry performance was examined in this study. The investigation was conducted in the Jalingo metropolis of Taraba State, Nigeria. Both correlational and quasi-experimental designs were used in the investigation. The study included 160 Upper Basic School II pupils as its sample. Data were gathered using two instruments: the Geometry Achievement Test (GAT) and the Attitudes Toward Geometry Inventory (ATGI). The instruments were validated, and for the ATGI and GAT, respectively, their reliability indices were calculated to be 0.86 and 0.91. The results indicate that while student performance in geometry is inversely connected with the laboratory style of instruction, student attitudes toward geometry are positively correlated. It has been found that 56% of students' success in geometry may be predicted by factors such as their attitude toward mathematics, gender, and instructional strategies used in laboratories. According to the correlation statistics, the laboratory method accounts for 74% of student performance in geometry, gender for 9.6%, and attitude for 7.9%. To foster a good attitude toward geometry, it is recommended that the laboratory method of instruction be promoted in mathematics class.

**Keywords:** Attitude, gender, laboratory method, performance in geometry

## Hubungan antara metode mengajar laboratorium, sikap siswa dan gender terhadap performa siswa dalam geometri

**Abstrak:** Hubungan antara metode pembelajaran laboratorium, sikap siswa terhadap geometri, dan jenis kelamin terhadap kinerja geometri diperiksa dalam penelitian ini. Investigasi dilakukan di kota metropolitan Jalingo di Negara Bagian Taraba, Nigeria. Kedua desain korelasional dan kuasi-eksperimental digunakan dalam penyelidikan. Penelitian ini melibatkan 160 siswa Sekolah Dasar II Atas sebagai sampelnya. Pengumpulan data dilakukan dengan menggunakan dua instrumen yaitu Tes Prestasi Geometri (TPG) dan Angket Sikap terhadap Geometri (ATGI). Instrumen divalidasi, dan untuk ATGI dan TPG, masing-masing indeks reliabilitasnya dihitung dengan perolehan 0,86 dan 0,91. Hasilnya menunjukkan bahwa sementara kinerja siswa dalam geometri berbanding terbalik dengan gaya mengajar laboratorium, sikap siswa terhadap geometri berkorelasi positif. Telah ditemukan bahwa 56% keberhasilan siswa dalam geometri dapat diprediksi oleh faktor-faktor seperti sikap mereka terhadap matematika, jenis kelamin, dan strategi pembelajaran yang digunakan di laboratorium. Menurut statistik korelasi, metode laboratorium menyumbang 74% kinerja siswa dalam geometri, jenis kelamin 9,6%, dan sikap 7,9%. Untuk menumbuhkan sikap yang baik terhadap geometri, disarankan agar metode pengajaran laboratorium diaplikasikan di kelas matematika.

**Kata Kunci:** Sikap, gender, metode laboratorium performa dalam geometri

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## INTRODUCTION

The importance of mathematics in helping students comprehend other subject areas and develop critical, logical, reasoning, analytical, creative, and systematic thinking skills cannot be overstated. Therefore, understanding mathematics is essential to every man's success in his daily endeavours. Mathematics education has the power to help people apply their mathematical understanding to common situations, so advancing their intellectual and financial stability. From the prehistoric era of the earliest human cultures to the current high technological era, mathematics has been crucial to the economic growth of *many* nations throughout the world (Agormor et al., 2022; Becker et al., 2022; Pangadongan et al., 2022; Popoola, 2012).

The advancement of science and technology is directly tied to the field of mathematics. A nation's level of advancement is based on how far it has come in science and technology. Additionally, the advancement of science and technology will determine the welfare of the country because they make a significant contribution to its economic growth and prosperity. This is why, regardless of the degree of economic, scientific, and technical advancement, mathematics is taught at the primary and secondary levels in every country. These days, a wide range of professions demand the ability to analyse issues mathematically and solve new ones. Therefore, it is obvious that mastering mathematics is crucial for every person and every country.

The performance of students in mathematics examinations is not encouraging, especially at the secondary school level, despite the immensity of its relevance to scientific and technical advancement around the world. It is alarming how frequently Nigerian students have performed poorly in mathematics on the Senior School Certificate Examination (SSCE) over the past 20 years. For instance, according to research by Zalmon and Wonu (2017), the pass percentage for students who take the SSCE conducted by the West African Examination Council (WAEC) between 1991 and 2016 was as low as 27.31%, with 72.69% of students failing. The SSCE failure rate follows the same pattern as the Basic Education Certificate Exam (BECE). For instance, in Taraba State, Nigeria, just 17.52 per cent of students who took the BECE examination in 2012 passed with a credit in mathematics (Taraba State Education Resource Centre, 2021). This shows how inadequate mathematics instruction and learning are in our educational system.

Many nations around the world are quite concerned about the prevalence of low mathematics achievement. To determine what causes the high percentage of mathematics failure, academics and mathematics educators have done several studies. Studies' findings have identified a variety of causes and factors that contribute. According to Hidayat and Iksan (2015), Lin et al. (2016), Udonsa (2015), and Zakaria and Syamaun (2017), traditional chalk-and-talk teaching techniques are one of the things that prevent secondary school pupils from comprehending and succeeding in mathematics. The performance of students in mathematics cannot be improved using conventional approaches.

Geometry is one of the areas of mathematics in which students have not been doing satisfactorily, according to the WAEC Chief Examiner's Report 2020. The study of the dimensions, contours, and positions of 3-dimensional and 2-dimensional figures is known as geometry (Russell, 2020). According to Gloria (2015), geometry is a rich source of knowledge that may be used in both theoretical and practical contexts. The development of students' analytical and reasoning skills will be aided by their working understanding of

basic geometric shapes, along with their attributes and relationships. In Nigeria and other nations, geometry is taught extensively in primary and secondary mathematics curricula. It offers a wealth of visual examples to help people comprehend mathematical, algebraic, and statistical ideas. Understanding geometry gives one a full understanding of the universe in which we live. Geological formations, the structure of the solar system, plants and flowers, stones and crystals, and even living things such as animals are instances of natural geometry. It also plays a significant part in the realm of synthetics, which encompasses nearly all human creations, including architectural models, artwork, machines, and cars. Geometry plays an essential role in daily life. Moreover, geometry has an essential part in the academic sector, such as in the fields of art, technology, and science. Geometry can be utilized to assist students in solving practical problems by first enhancing their spatial awareness, visualization abilities, and intuition (Sulistiowati et al., 2018; Sunzuma et al., 2012).

Despite its significance, it has been found that among other things, inadequate geometric reasoning skills, an absence of visualising ability, a teacher's style of lessons, and the absence of teaching materials are some of the reasons that make it difficult for students to learn geometry (Fabiya, 2017). These circumstances make it challenging for students to grasp the fundamental ideas and develop the abilities required for learning and understanding mathematics, which leads many to label the subject as a "myth." Due to this hindsight, the students grow to dislike the subject. Their negative attitudes are reflected in how they approach learning mathematics.

According to theory, an attitude is a psychological construct that consists of three parts: affective, cognitive, and behavioural (Verešová & Maláa, 2016). The cognitive component refers to a person's belief or knowledge about an object, while the affective component deals with a person's emotions or feelings about an object (Alake, 2015; Verešová & Maláa, 2016). The behavioural (or conative) component describes how attitude influences one's actions or behaviours. A subfield of affective research, attitude is distinct from emotion since it is more cognitive and steadier (Hannula et al., 2016). Additionally, since attitude is less cognitive than belief, it differs from belief (Hwang & Son, 2021). This is because, in contrast to attitudes, which are actions, feelings, or thoughts that reflect one's disposition or opinion, beliefs are psychologically maintained understandings of the universe's premises or propositions (Philipp, 2012). As a result, attitude can be defined as a reasonably consistent psychological tendency with a given level of positive or negative toward a specific idea, object, or entity (Clare & Schnall, 2005).

Experiences with a thing can help shape one's attitude toward it. This means that as students' psychological states are influenced by their cumulative encounters with a particular object or subject, they either form a favorable or unfavorable viewpoint on what happened. As a result, students usually exhibit consistent behavior and thoughts with their attitudes. This explains why, according to Mullis et al. (2020), students who have a positive attitude about mathematics are more likely to enjoy the subject, see it as worthwhile, and feel confident in pursuing it. Because of this, Sunghwan and Taekwon's definition of students' attitudes toward mathematics as their overall evaluation of mathematics in 2021 stands.

Verešová and Maláa (2016) opined that a student's attitude about a subject has a significant role in his ability to perform well in school. Sejšová (2006) states that a person's

attitude toward a subject indicates his level of popularity, which in turn represents his propensity to execute the actions the subject requires and the pleasure he derives from doing so. Students may have good or negative attitudes toward a lesson. Positive or negative attitudes are ingrained convictions that remain constant and unchanging as a result of the experiences of the students (Sirmaci, 2010). Students who approach a subject with a positive attitude do well in it, whereas those who approach it negatively do poorly (Velloo et al., 2015). According to Kubiato (2018), when students have positive attitudes towards a subject and their school, it shows in their academic performance as well.

Students have trouble learning mathematics because they lack interest in the subject and have negative attitudes about it because mathematics is thought to be a tough and obscure subject (Ganal & Guiab, 2014). Students' attitudes toward mathematics are defined by Zan and Di Martino (2007) as the emotional response—whether positive or negative—associated with mathematics, confidence in one's ability to succeed in studying mathematics, and coping mechanisms. Numerous studies have examined how students feel about mathematics. For instance, according to Güner (2012), a student's attitude toward mathematics plays a significant impact in deciding how well they learn the subject. Students who have positive attitudes toward mathematics will perform well academically.

Students' attitudes toward mathematics and performance are significantly correlated (Ajisukmo & Saputri, 2017; Dowker & Sheridan, 2022; Hwang & Son, 2021; Peteros et al., 2019; Sirmaci, 2010). According to Asante (2012), male students have a more positive attitude toward mathematics than female students do. According to Güner (2012) research, attitudes toward mathematics were unaffected by differences in gender. Girls appear to have more positive views, according to the study by Candeias et al. (2010), whereas boys are less motivated and have more negative attitudes.

Many elements influence how students feel about a subject, but the teacher and his teaching method come in first. According to studies, mathematics teaching methods have an impact on students' favourable views toward mathematics (Sirmaci, 2010). The instructional strategies have an impact on student attitudes (Zudonu & Njoku, 2018). This brings back memories of my secondary school mathematics experiences. The mathematics teacher we had back then was the kind that would walk around the classroom and demonstrate problems on the chalkboard before going over the solution(s) with the class. The worked examples will be copied by the students, and this is typically followed by class and homework. Little to none of what the teacher did in class was understood by the students. Students begin to despise mathematics and the teacher as a result. Thus, the students' attitude was negative. This particular group of students would not consider mathematics to be beneficial or significant. As a result, for learning to be relevant and for improved concept formation, the learner's attitude toward a subject and the teacher's teaching methodology is essential.

There is no denying that mathematics deals with some abstractions, but the mathematics teacher must constantly work to generate enough excitement in the classroom activities to prevent the subject from being viewed as dry and monotonous. The students must make mathematics a favourite and fun subject if they are to achieve this. The teacher can accomplish this by implementing leisure activities that promote a positive attitude in students and proper and efficient mathematics learning. Teachers utilise a variety of

techniques and approaches to teach and learn mathematics that has been shown to raise students' arithmetic proficiency. The laboratory method is one of them.

The mathematics laboratory is a space that has a variety of resources and teaching/learning tools that are necessary to enable students in understanding mathematical ideas through engaging, practical, and meaningful activities (Maheshwari, 2018). These exercises can be completed by the teacher or the students to explore the world of mathematics, learn about it, and get interested in it. The laboratory of mathematics is a special room equipped with the latest and relevant tools known as instructional materials, which function for the teaching and learning of mathematics, making scientific work or research processes, where mathematics teachers as individuals who are trained and have professional qualifications can easily carry out interaction with students on a set of instructions that have been designed and planned (Adenegan, 2003).

The laboratory method is a way of teaching and learning mathematics that gives students the chance to use their own experiences to break down abstract mathematical concepts. That is, to connect symbols to the real world. The laboratory method of teaching mathematics is a method in which the teacher forces the students to study the subject by carrying out experiments and laboratory work in a dedicated space for math, much as how they learn the sciences by carrying out similar activities in scientific labs. Students learn mathematical facts using the laboratory approach. The psychological concepts of learning by doing, learning by observing, and moving from the concrete to the abstract are the foundation of it (Sidhu, 2006). The laboratory approach is very effective at connecting theoretical knowledge with a practical foundation (Frabun et al., 2018). With this strategy, learning becomes more engaging, vivid, and meaningful .

There are very few mathematics laboratories in our schools today, which may be due to a lack of funding or the absence of a government policy mandating the construction of such facilities. Mathematics laboratories are relatively new in the teaching and study of mathematics. One of the main causes of widespread mathematics failure in our schools is the absence of mathematics laboratories (Adenegan, 2003). When used, the laboratory approach has primarily been applied in the social and medical sciences, with little thought given to mathematics teaching.

The laboratory technique is effective in studies by Ojediran et al. (2014), Okigbo and Osuafor (2008), who found that using mathematics laboratories improved mathematics performance. There are numerous studies on various teaching strategies as well. Studies that have looked at how students' attitudes about mathematics compare to teachers' teaching strategies and how well students succeed in mathematics are scarce, nonetheless. With this knowledge in mind, this study examined how the laboratory teaching method, students' attitudes toward mathematics, and gender impacted their performance in geometry.

## **METHOD**

This study employed a quasi-experimental design with non-equivalent pre- and post-test groups. Where existing classes were used, total randomization of the research subjects was practically impossible, which turned the design into a quasi-type. The sample was split into two groups: group A was the experimental group, which applied the method, and group B was the control group, which applied the conventional method. The entry level of the two

groups was established through pre-testing. After six weeks of in-class teaching on particular geometrical themes, both groups received a post-test. On the dependent variable, a pre-test and follow-up test were administered (achievement).

The equivalence of the groups could not be assured because the study used intact (existing) classes, which is another reason for the non-equivalent group design. However, the pre-test was utilised to assign students to an equivalent group. Gain scores following treatment were obtained using the post-test. According to Sambo (2005), using measurement techniques and materials that produce accuracy and objectivity makes the quasi-experimental design more reliably carried out. The students were divided into the control group (C) and the experimental group while still in their intact courses (E). 160 Upper Basic School (class II) pupils from two schools in the Taraba State capital of Jalingo made up the study's sample. Utilizing the purposive sample technique, the schools were chosen. The objective was to find mathematics teachers that hold a bachelor's degree in mathematics education (B. Sc (Ed) degree) and at least three years of classroom experience. Thus, the schools were divided into experimental and control groups using a straightforward random sampling technique. The study involved using participants in their complete classes. A specially created methodology instructional package (MIP) was used to teach the groups.

The MIP are lesson plans that have the same curriculum materials but use different methods of instruction. The control group's educational activities were conducted in a traditional classroom environment. A laboratory environment served as the MIP for the experimental group, where students learned through practical exercises like experiments and laboratory work in the mathematics classroom. The Geometry Achievement Test (GAT) was used to collect data on achievement, and the Attitudes Toward Geometry Inventory (ATGI) was used to collect data on attitude. The GAT consists of 50 multiple-choice items with 4 possible answers. Ten lessons lasting 40 minutes each were used to teach the students the concepts for the objects, which are related to geometry. There are two parts to the ATGI (A and B). The demographic information of the respondents is in Section A. Section B, on the other hand, is a four-point attitude scale that asks students about their views on mathematics. The 20 items were given a Likert-type rating of strongly agree (SA), agree (A), disagree (D), and strongly disagree (SD).

Three experts in the area of mathematics education, science education, and educational evaluation and measurement assessed the GAT and ATGI for face, content, and construct validity. The item analysis that followed the validation produced a reliability index of 0.91 for the GAT using the K-R20 method and 0.86 for the ATGI using the Cronbach alpha coefficient method.

Standard multiple regression was used for data analysis (SRM). Each independent variable in SMR is assessed based on its predictive potential relative to all other independent variables. The ability of each set of independent variables (attitude toward mathematics, laboratory method, and gender) to predict students' performance in geometry (dependent variable) was thus explained using SMR. Additionally, it reveals the amount of unique variance that each independent variable contributes to the explanation of the dependent variable relative to the other independent variables in the set.

## RESULTS

The correlation matrix in Table 1 indicates that there is a strong but negative relationship between laboratory methods of teaching and students' performance in geometry (-0.74). The correlation between students' performance in geometry and attitude towards mathematics is moderate but negative (-0.45), while it is positive but very weak for gender (.004). The correlation between attitude and laboratory method and attitude towards mathematics is strong and positive (0.62), while the correlation between laboratory method and gender is negative and weak (-0.11). The correlation between attitude towards mathematics and the gender of the student is also negative and weak (-0.08).

Table 1. Correlation matrix of laboratory method, attitude and gender on student's performance in geometry

Grp	N	performance	Lab Method	Attitude	gender
<b>Pearson Correlation</b>	Performance	-	-0.742	-0.447	0.004
	Lab Method	-0.742	-	0.618	-0.114
	Attitude	-0.447	0.618	-	-0.081
	Gender	0.004	-0.114	-0.081	-
<b>Sig. (1-tailed)</b>	Achievement	-	0.000	0.000	0.480
	Lab Method	0.000	-	0.000	0.076
	Attitude	0.000	0.000	-	0.153
	Gender	0.480	0.076	0.153	-
<b>N</b>		<b>160</b>	<b>160</b>	<b>160</b>	<b>160</b>

The correlation between students' performance in geometry and laboratory method, students' performance and students' attitudes towards mathematics are statistically significant. Similarly, the correlation between the laboratory method and student's attitude towards mathematics is also statistically significant. Conversely, the correlation of students' gender with the laboratory method, students' attitudes towards mathematics, and performance in geometry are not statistically significant.

Table 2. Regression model on the prediction of students' performance in geometry by attitude towards mathematics and the laboratory method of teaching?

Model	SS	df	MS	F	Sig	R	R <sup>2</sup>	Adjusted R <sup>2</sup>
Regression	3581.17	3	1193.79	65.52	0.000 <sup>b</sup>	0.75 <sup>a</sup>	0.56	0.55
Residual	2842.41	157	18.22					
Total	6423.78	160						

a. Predictors: (Constant), attitude, laboratory method

b. Dependent Variable: Achievement Score

The regression model in Table 2 shows a coefficient of determination; R-squared = 0.56. That is 56% of the variance in students' performance in geometry is attributable to their attitude towards mathematics, the laboratory method of teaching and their gender. The prediction model statistically is significant  $F(3, 157) = 65.52$ , since  $p < 0.005$ .

Table 3. Relative contributions of attitude, gender and laboratory method on students' performance in geometry

Model	B	$\beta$	t	Sig.	Zero-Order	Part	partial
Constant	33.981	-	18.826	0.000	-	-	-
Lab method	9.535	0.742	13.843	0.000	0.742	.0733	0.742
Gender	-1.212	-0.096	-1.765	0.079	0.004	-0.093	-0.140
Attitude	0.721	0.079	1.452	0.149	0.155	0.007	0.115

The raw and standardized regression coefficients of the predictor variables together with their structure coefficients are shown in Table 3. The laboratory method received the strongest weight in the model (0.74 or 74%), followed by gender (0.096 or 9.6%), and the least attitude (0.074 or 7.4%). Inspection of the structure coefficients shows that only the laboratory method has a significant effect.

## DISCUSSION

The results of this study showed a negative link between students' geometry test scores and the laboratory method of instruction, but a positive correlation between the laboratory technique and students' attitudes toward mathematics. The laboratory method and students' attitudes toward mathematics have a positive link, which suggests that the method can help students develop favourable attitudes toward mathematics. The results of this study also show that there is no statistically significant relationship between gender and other factors (laboratory method, mathematics student attitude, and geometry student performance). The prediction model demonstrates that the combined influence of the three components (laboratory method of instruction, students' attitudes toward mathematics, and gender) accounts for 56% of variances in students' performance in geometry. Despite the fact that there is a strong negative link between the laboratory approach and students' geometry proficiency, it is statistically significant. Here, another element or the correlation's occurrence by coincidence rather than as the result of any causal variables is the most plausible explanation.

The results of this study support other findings Ajisuksmo and Saputri (2017), Dowker et al. (2019), Hwang and Son (2021), Kiwanuka et al. (2022), and Peteros et al. (2019) that It discovered a link between students' attitudes on mathematics and their mathematical achievement. A positive link suggests that students' willingness to learn mathematics is influenced by their attitude about the subject. An expectancy-value hypothesis, which contends that students' perceptions of the relative cost, interests or enjoying, attainment, and utility values of a certain subject all affect their performance, can further explain this. This may have something to do with the fact that the laboratory method of teaching mathematics gives students the chance to comprehend and absorb fundamental mathematical ideas.

The regression equation;  $y = 33.981 + 9.535x_1 - 1.212x_2 + .721x_3$ , shows the individual contribution of predictors (laboratory method, attitude and gender). The regression shows that the laboratory method has the highest weight (74%), followed by gender (9.6%) and attitude (7.4%) came last. Of all the predictors, only the laboratory



method is significant. This finding affirms the position of Brusa and Lupardus (2020), Piliang and Damopolii (2021), and Sneddon and Douglas (2013) that students appreciate laboratory learning as a means to develop knowledge and skills. This goes further to explain why the students performed creditably in geometry with the use of the laboratory method. The corollary is that if students are taught with a method that makes them understand mathematics, their attitude towards mathematics will be positive which will in turn propel them to like the subject and the results will be a good performance.

## CONCLUSION

According to this study, students' attitudes toward mathematics in the laboratory method of instruction positively influence their performance in geometry. However, there is no discernible relationship between student gender and academic achievement, attitude toward mathematics, or the laboratory method of instruction. Considering this, the study suggests using the laboratory method of instruction to promote a favourable attitude toward mathematics.

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