



## Effect of Inquiry-Based Teaching Methods Enhance Math Performance? A Pakistani Student Perspective with Math Attitude as a Mediator

**Amil Hussain**

School of Mathematical Sciences, Shanghai Key Laboratory of PMMP, East China Normal University, Shanghai China

Email: hussainamil003@gmail.com

**Hasnain Khan**

School of Mathematical Sciences, Shanghai Key Laboratory of PMMP, East China Normal University, Shanghai China

Email: hasnainkhanmath1@gmail.com

### ABSTRACT

Mathematics education in Pakistan continues to face significant challenges, with students consistently underperforming in international assessments. This study analyses the impact of Inquiry Based Pedagogy (IBP) on Student Math Performance (SMP) while exploring the mediating role of student math attitude (SMA). Using statistics derived from 2019 TIMSS (Trends in international Mathematics and Science Study), we analyse responses from 4,327 fourth-grade students across Pakistan. Structural equation modelling (SEM) reveals that there is strong positive effect of IBP on SMA ( $\beta = 0.404$ ,  $p < 0.001$ ), fostering greater learners' engagement and confidence in mathematics. SMA, in turn, has a moderate but significant effect on SMP ( $\beta = 0.051$ ,  $p < 0.001$ ), suggesting a positive math attitude enhances academic achievement. Additionally, IBP directly improves SMP ( $\beta = 0.063$ ,  $p < 0.001$ ), indicating the instructional benefits of inquiry-driven learning. Findings from the mediation analysis indicates that SMA play a significant role in linking IBP to SMP, though its contribution is relatively modest ( $\beta = 0.009$ ,  $p < 0.001$ ). These findings emphasize the effectiveness of IBP in enhancing math learning outcomes, particularly through improved instructional quality and student engagement. However, disparities in access to educational resources, especially between urban and rural areas, hinder widespread adoption. Policy suggestions involve specialized teacher training, curriculum adjustments, and positive attitudes towards math. This research contributes to the discourse on math reform in Pakistan and provides evidence for instructionally driven strategies to enhance student performance.

**Keywords:** Inquiry Based Pedagogy, Math Performance, Math Attitude, TIMSS, Pakistan

### Introduction

Mathematics is a foundation of intellectual development and an important factor in determining students' future academic and professional lives. Yet, the students in Pakistan still struggle with mathematics as per trends in international and mathematics and science study (TIMSS). In this evaluation, more than five thousand 4th grade students who took part from Pakistan, and the findings indicated that they scored well below the international average, indicating severe gaps in mathematical knowledge, problem-solving ability (Mullis et al., 2020). In 2025, a research conducted in Sindh province revealed gender differences, with rural students falling behind their suburban classmates due to resource limitations and multi-grade instruction ( $\beta = -0.89$ ,  $p$



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$< 0.001$ ) and female students scoring worse than men ( $\beta = -0.45$ ,  $p < 0.05$ ) (Numajiri & Kosaka, 2025).

The reason for this poor performance is the system in Pakistan encourages students to memorize instead of getting involved in more critical thinking (Ali, 2018). The problem is also aggravated when we look at urban school vs rural school situations, since elementary and secondary schools in urban areas enjoy better resources and staff, while schools in rural areas which make up 59% of the TIMSS sample, find it especially tough to recruit competent teacher (Mullis et al., 2020).

To overcome these limitations, inquiry-based pedagogy (IBP) which follows the ideas of constructivist learning, offers a new and effective approach. As reported (Bada & Olusegun, 2015), IBP supports students as they find answers, review issues and gain mathematical knowledge by stepping away from classes taught by the teacher alone and towards classes where students are more involved. IBP was shown to be more effective in a 2024 study conducted in Vietnam, in which SMA mediating its effect on SMP (std.  $\beta = 0.07$ ,  $p < 0.001$ ) (Alvarado & Galigao, 2024). In addition to foster deeper conceptual understanding and metacognitive skills—both are essential for long-term academic success in mathematics. Alongside strengthening deeper understanding and metacognitive skills which benefit students long-term in mathematics, IBP seeks to encourage students' enjoyment, urge them forward and instill belief in their abilities to learn math (Ma & Kishor, 1997).

Student with positive Math attitudes (SMA) are proven to endure difficulty and are more likely to be involved in problem solving which helps them accomplish more in mathematics-related tasks (Berger et al., 2020; Zafeer et al., 2025). Even after its proven success worldwide, inquiry-based pedagogy (IBP) is not widely accepted in Pakistan due to outdated teaching guides, less instruction for teachers and few resources in remote areas (Ali, 2018). In this context, there is not enough research on how IBP relates to SMA and its effects on SMP in Pakistan.

It is necessary to make specific changes to use the IBP method in Pakistan. Researchers in Karachi found that IBP can be introduced by modifying the classroom, adjusting teacher and student responsibilities, increasing student independence and changing assessments (Khan, 2012). With time, teachers begin to guide IBP to a higher level of directed inquiry. For long-term use, it is important that everyone cooperates and continues their professional development (Twigg, 2010). This has made it obvious that there is a need for particular solutions to help with implementation where resources are low.

To solve this issue, SEM was used to analyze data from 4,327 Pakistani fourth-grade students in this study. It investigates both the direct impact of IBP on SMP such as skill enhancement in the classroom and indirect impacts such as enhancing school morale. The researchers also considered factors in society such as gender and the differences between cities and rural areas, that may hold back IBP. This study presents facts that help educators in Pakistan find new, successful ways to teach math, since enhancing math skills there will help reduce inequality and increase the nation's competitiveness in the global market (Makar, 2024).

The research can guide similar nations facing the same problems and contributes to the worldwide knowledge on learning with limited resources (Antoninis et al., 2023). It suggests that Pakistani teachers and leaders use student-friendly teaching, invest in proper teacher training and make educational resources available to improve math education for children from rural and urban areas



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### Literature Review

All over the world, the way mathematics is taught is shifting as there is a greater need for people to think critically, solve problems, and apply their knowledge to real situations. The TIMSS analysis by (Mullis et al., 2020) found that different international countries, including Pakistan, had significant difficulties in mathematics among their Grade 4 students, contributing to high gaps in scores. Some research reports have shown that in Pakistan, the lack of support in curriculum, instruction, and materials has negatively influenced student performance (Ali, 2018).

IBP is based on constructivism, which says that students actively learn by participating in activities, asking questions, and solving problems (Bada & Olusegun, 2015) Unlike traditional teaching that mainly asks students to memorize, IBP encourages them to find new ideas, work with their peers, and look back on their experiences. In his study, (Thompson, 2008) asserts that IBP stimulates students' skills in communicating math problems, visualizing them, and reasoning logically. Also, (Alvarado & Galigao, 2024) reveal that IBP encourages students to be responsible for their own learning experiences.

Many studies have shown that students' beliefs and attitudes toward mathematics greatly affect their school results. When students have confidence, interest, and respect for mathematics, their motivation and abilities improve (Berger et al., 2020; Ma & Kishor, 1997) Students who develop a positive attitude toward math took part in more difficult mathematics problems, and this also helped them gain greater confidence in their own abilities (Zafeer et al., 2025). Learning in inquiry-focused classrooms helps students which leads to stronger SMA (Hoferichter & Raufelder, 2015).

Though many parts of the world embrace active learning pedagogies, Pakistan remains hindered by issues that prevent it from innovating in instruction. The majority of classrooms in rural regions are still run by one teacher lecturing to a group, mostly due to shortages in technology, resources, and education for teachers (Khan, 2012). In rural areas, girls are often stopped from going to school and achieving success because of the strong belief systems in their cultural group (Numajiri & Kosaka, 2025).

The assessment in TIMSS 2019 forms a reliable database to study teaching and learning systems worldwide. (Wang et al., 2024) discovered that using inquiry and conceptual understanding in teaching helped students perform significantly better in different settings. The TIMSS data analyzed by (Jerrim et al., 2022) proved that students learning through inquiry had better performance than those in more traditional classrooms. However, different countries had different effects because of their individual circumstances, which shows how important it is to tailor reforms to each place.

The importance of IBP is generally agreed upon, yet there is little data explaining how it affects student behavior and achievement in Pakistan. A limited number of studies have depended on structures methodologies, for instance, structural equation modeling, to find the impact of SMA in the link between IBP and SMP. This research is designed to help fill this gap by relying on TIMSS 2019 and interpreting the data within Pakistan's primary school system, giving helpful advice for educational and governmental improvements.

The current research suggests significant changes are needed in the way primary mathematics Education is offered in Pakistan. According to (Callaghan et al., 2018), making schools better for students needs redesign of the curriculum, professional development for teachers, and regular monitoring of teaching. (Alam & Mohanty, 2023) encourage using ICT and inquiry learning to increase students' interest and let them direct their own learning projects. It requires Pakistan to create strategies that handle local issues and support innovative ways of teaching (Mullis et al., 2016). The studies reviewed highlight that Inquiry-Based Pedagogy and



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Students' Mathematics Attitude contribute greatly to better mathematics performance among students. Such components matter a lot in Pakistan, since typical education practices have not led to expected results there. Relying on the data from TIMSS 2019, this study gives practical solutions for understanding the links between teaching approaches and students' attitude toward learning, which can help guide future school reforms

### Objectives of the Study

This research aims to examine the complex interrelationship between the math attitude (SMA) of the students and the math performance (SMP) of students in the Pakistani educational setting. To quantitatively measure the direct effect of SMA on SMP, the structural equation modeling (SEM) is a powerful statistical method that is utilized in the research. This approach will permit the detailed analysis of complex interdependences between observed and latent variables, and will give a subtle insight into these constructs.

Moreover, the study will attempt to investigate how SMA may mediate the relationship between inquiry-based pedagogy (IBP) and SMP. It is theorized that SMA is a critical intervening variable, which is determining the ultimate outcome of the adoption of inquiry-based teaching strategies on the mathematical performance of the students. It will be possible to use SEM to help the intensive scrutiny of this hypothesized mediating pathway with the view to providing an insight into the underlying mechanisms that relate the pedagogical strategies to student performance.

Through the use of SEM, this study aims at making an important contribution to the current body of literature in terms of offering empirical data on the dynamics of math attitude and performance in Pakistan and the indirect impacts of innovative teaching techniques. The results are hoped to provide useful educational policy and practice implications, which will be able to help in structuring an intervention that will improve the attitude and improve the performance of the students in math.

### Hypotheses of the Study

The present study addresses the following hypothesis, as illustrated in fig 1

H<sub>01</sub>: There is no substantial relationship between students' math attitude (SMA) and students' math performance (SMP) in Pakistan via structural equation modeling

H<sub>02</sub>: There is no mediating effect of student math attitude (SMA) on the relationship between inquiry-based pedagogy (IBP) and students' math performance (SMP).

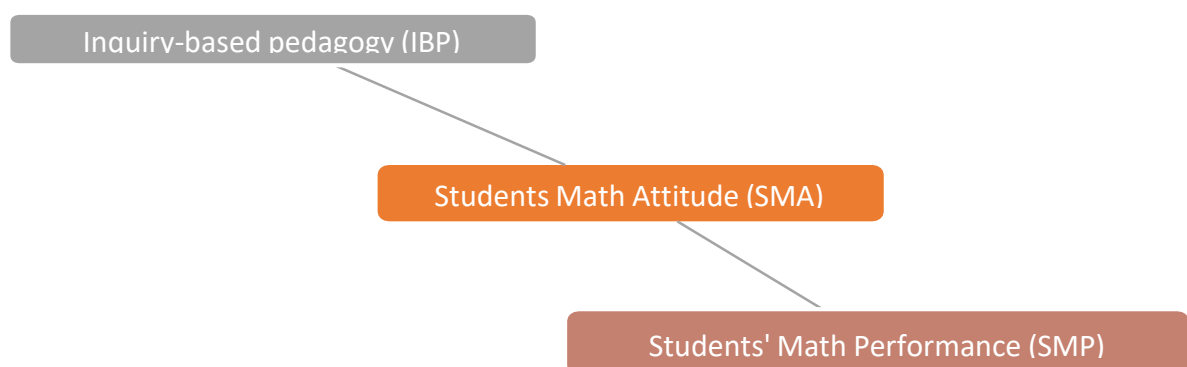


Fig 1 Hypothesis between IBP, SMA and SMP

### Methodology



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### Participants and Sample

The quantitative data were obtained through publicly available dataset from the Trends in International Mathematics and Science Study (TIMSS) 2019 which is one of the major international assessments in measuring performance of students in Pakistan. This study is dedicated to the performance of fourth-grade students in mathematics.

The original sample in TIMSS 2019 included 5,000 students at the fourth grade. Out of this starting sample, 173 students were dropped because of class or school dropout, and 137 students were not used in the assessment owing to reasons recorded in TIMSS data and 4,690 students were used. Not all these eligible students were present on the day of evaluation and thus, 4,458 students were successfully evaluated in 232 of the eligible students.

The cleanup of data was done in a careful manner to promote the integrity and the strength of the analytical sample. The dataset had been reduced systematically by 131 students (4,458 and 4,327 respectively). The first exclusion criterion was the lack of data on the major variables that were necessary in this research such as the performance scores of students in mathematics as well as self-reported questions on math attitude or teacher-responses on inquiry-based pedagogy. This sample screening is indicated conceptually in a flow chart (Figure 2), which outlines the flow of the originally sampled population to the final sample of analysis of 4,327 students.

### Variables and Measures

The paper examines the connection between inquiry-based learning, student attitude towards math and their performance in mathematics. Variables and measures used were the following ones:

**Mathematics Performance:** The mathematics performance of the student was directly determined by the values that are feasible in the dataset that was released by TIMSS in 2019. This result is a direct indicator of the skills of the students in the primary field of the test.

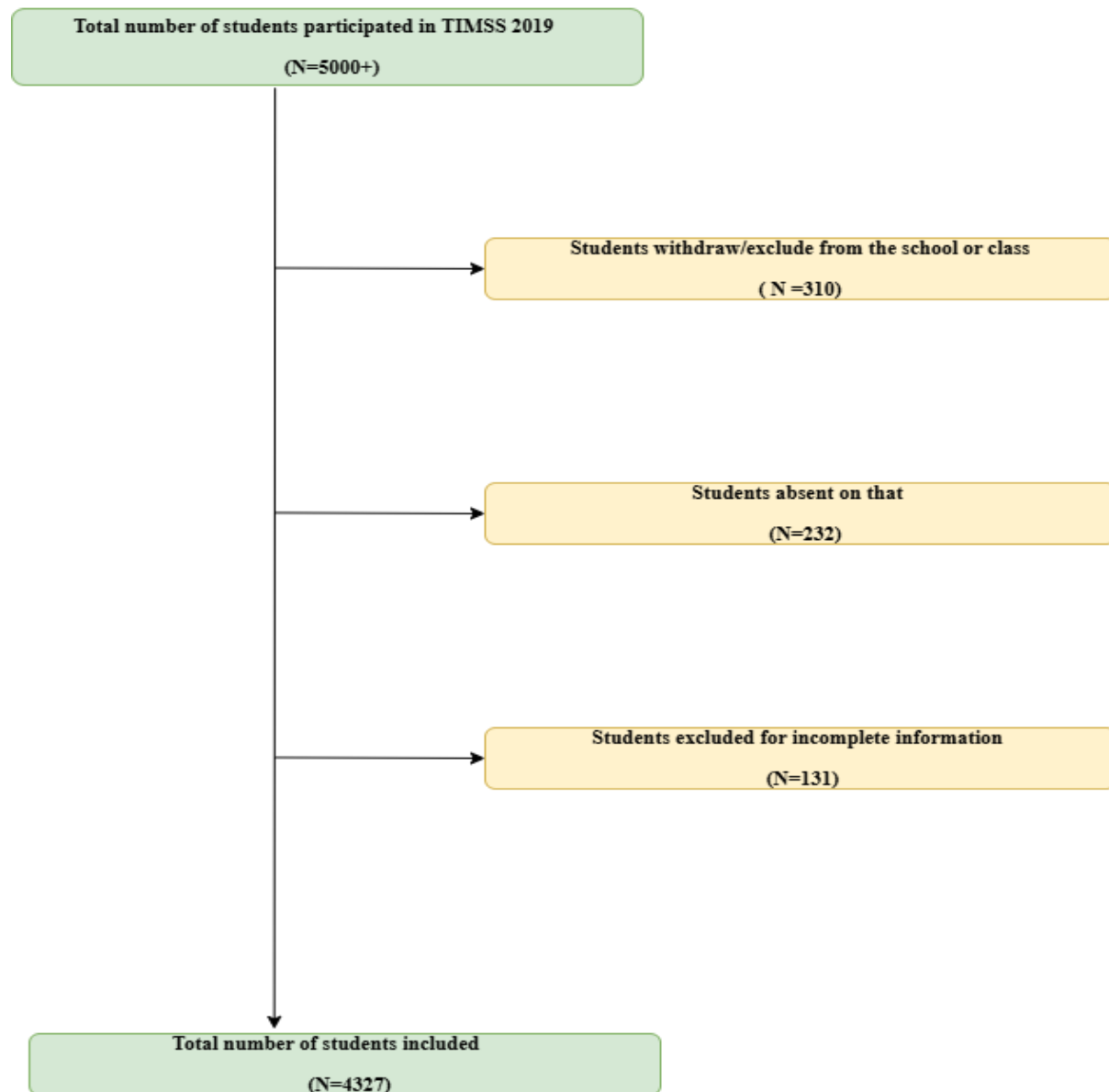
**Student Mathematics Attitude:** The attitude of students towards mathematics was evaluated through a scale which was based on self-reported questions in the TIMSS student Questionnaire. This index reflects the beliefs, fun and confidence of students on the subject.

**Inquiry-Based Pedagogy:** Inquiry-based teaching practices were assessed using a composite scale, which was based on items in the TIMSS teacher questionnaire. These items show the frequency and the kind of inquiry based instructional strategies adopted by the involved mathematics teachers.

The fact that the TIMSS 2019 assessment focuses on mathematics as a significant area gives the inputs to the variables and measures that will be adopted in the study, which will align the scope and goals of the study.



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**Fig 2** Flowchart of subject inclusion

### Data Analysis

The statistical methods adopted to analysing the data of this research were done in SPSS Statistics (Version 22) and Amos (Version 24). To begin with, the descriptive statistics were calculated in SPSS to describe the demographical trends and sample attributes of 4,327 fourth-grade students to get a picture of the distribution of the most important variables. All multi-item scales were then performed again to test their reliability through Cronbach's alpha to determine that they had internal consistency and therefore a stable latent construct.

To test the measurement models of the constructs (e.g., student math attitude, inquiry-based pedagogy), an exploratory and confirmatory factor analysis were conducted using the SPSS and Amos respectively. Before the factor analysis, Kaiser Meyer Olkin (KMO) sampling adequacy parameter and the Bartlett Test of Sphericity were used in the SPSS to determine the



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appropriateness of the data in order to extract factors. After testing the measurement models, Structural Equation Modelling (SEM) was obtained using Amos.

This powerful multivariate method enabled the direct and indirect effects to be estimated simultaneously, that is, whether student math attitude (SMA) is a mediator of the relationship between inquiry-based pedagogy (IBP) and student math performance (SMP). The mixture of SPSS and Amos was used as the guarantee of the thorough and strict methodology, as the initial screening of data and the descriptive analysis were followed by the sophisticated modelling of the complicated relations.

### Results and Discussion

This section shows the research results regarding the research interests that examined the correlation between inquiry-based pedagogy (IBP), student math attitude (SMA) and student math performance (SMP) between 4,327 secondary school students. The analysis will start with a descriptive account of the demographic facts of the sample, measurement indicators of IBP and SMA as well as the final results of the structural equation modeling (SEM) as a result of the mediation analysis. The descriptive statistics are described, the reliability provided, and the model fit indices reported to guarantee the full transparency and support the validity of the reported findings. These findings are interpreted in the following discussion based on the existing research on education, and implications are made based on these in the context of teaching math, especially in rural and public schools.

### Demographic Characteristics of the Respondents

The sample size of the study was 4,327, secondary school students, who were mainly of public schools in the rural setting hence providing a relevant picture of the secondary education in the resource constrained set up. A bar chart can be used to depict the distribution of important demographic variables as graphically illustrated in Figure 3. The chart indicates a significant percentage of students in the public school (79%) and rural (59 percent) students with an average age of 15 years. The sample mean math test score was 328 points whereas the socioeconomic status did not have a positive mean suggesting that the sample may experience economic difficulties.

In Table 1, the numerical data are given in the respective tables in terms of the means and standard deviations (SD). The actual mean age was 15.00 years ( $SD = 0.85$ ), and the grade level of students was 10.40. The sample was made up of 79.00 % of students of the public school and 59.00 % of rural and 41.00 % urban geographic distribution. The mean of socioeconomic status was -1.10 ( $SD$

= 3.00) with a variability indicating a low socioeconomic status in general and this factor can affect the learning results. The mean points of math test were 328.00 ( $SD = 62.00$ ), indicating rather moderate results with a significant dispersion, which could be explained by pedagogical and attitudinal issues of this study.



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Fig3 Demographic data of respondents

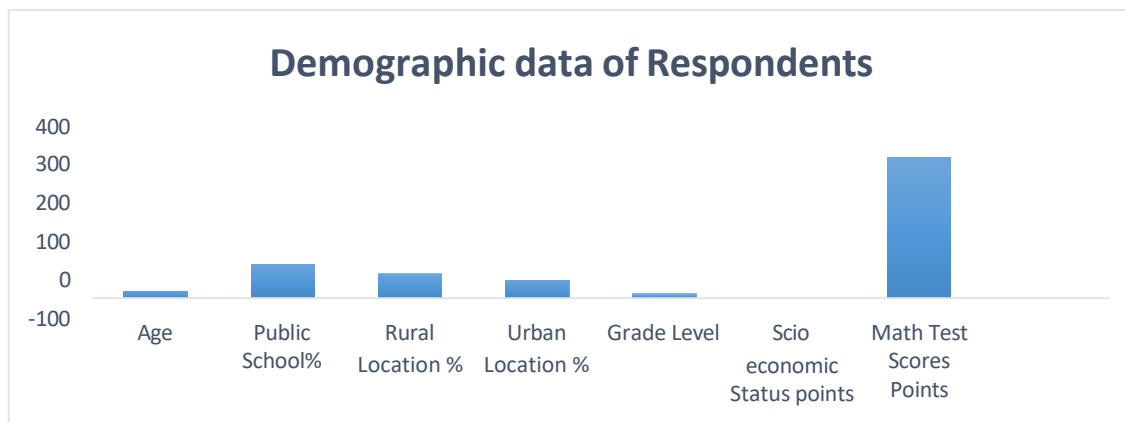


Table 1

Demographic data of respondents (N=4327)

Variable	Mean	SD
Age	15.00	-
Public School (%)	79.00	-
Rural Location (%)	59.00	-
Urban Location (%)	41.00	-
Grade Level	10.40	-
Socioeconomic Status (points)	-1.10	3.00
Math Test Scores (points)	328.00	62.00

These socio-demographic factors are consistent with the general educational patterns in the developing settings in which rural and less-privileged students are often exposed to obstacles to quality education. The rural bias that was observed in the sample increases the ecological validity of the results in relation to policies that will seek to deliver equal education especially since previous studies have revealed that such groups of students have a chance to benefit disproportionately through interactive approaches to teaching. This basic demographic background gives the much needed background information in the explanation of the following analysis of IBP, SMA and SMP.

### Inquiry-Based Pedagogy Measures

The evaluation of the inquiry-based pedagogy was carried out on seven indicators (IBP1 to IBP7) that were pegged on the answers given by students in a five-point Likert scale. The indicators are shown on a line chart (Fig. 4), the mean is ranging between 3.11 and 4.21, the standard deviation is ranging between 1.03 and 1.44 and factor loading is between 0.68 and 0.90. The chart demonstrates that IBP3 (mean = 4.21) and IBP4 (means = 3.55) are more commonly agreed upon, which proves that the following practices are more commonly perceived encouraging exploration and challenging.



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The mathematical measures are presented in Figure 3. They included: IBP1 (3.31, SD = 1.44, loading = 0.76), IBP2 (3.70, SD = 1.37, loading = 0.81), IBP3 (4.21, SD = 1.15, loading = 0.75),

IBP4 (3.55, SD = 1.03, loading = 0.90), IBP5 (3.11, SD = 1.44, loading = 0.70), The factor structure

was tested and found to be adequate based on the Kaiser-Meyer-Olkin (KMO) measure (= 0.828) and with the test of Sphericity significant (= 12,862.390, df = 21, p = 0.004)

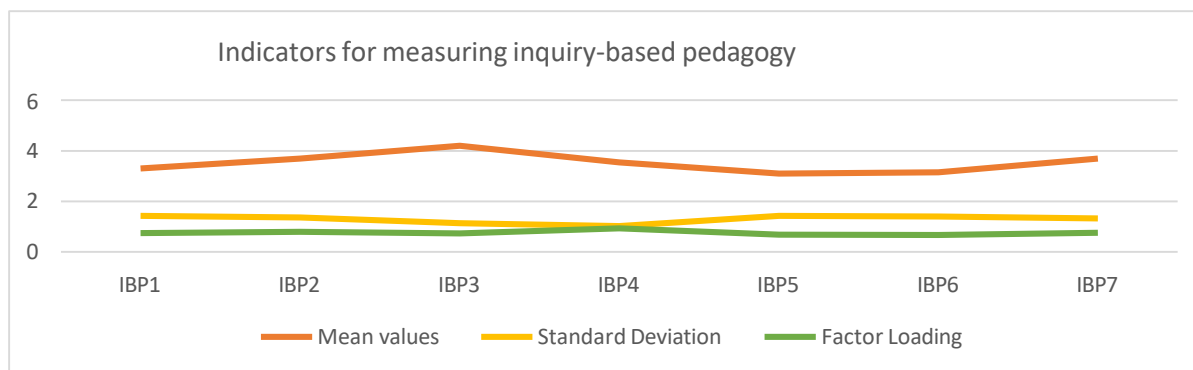


Fig4 Indicators for measuring inquiry-based pedagogy

Table 2 Indicators for measuring inquiry-based pedagogy

Statement	Mean	SD	Factor loading
<b>IBP1</b>	3.31	1.44	0.76
<b>IBP2</b>	3.70	1.37	0.81
<b>IBP3</b>	4.21	1.15	0.75
<b>IBP4</b>	3.55	1.03	0.90
<b>IBP5</b>	3.11	1.44	0.70
<b>IBP6</b>	3.16	1.42	0.68
<b>IBP7</b>	3.70	1.34	0.77

The Cronbach’s alpha is recorded at 0.805, while the Kaiser–Meyer–Olkin measure of sampling adequacy stands at 0.828. Bartlett’s test of Sphericity, has a statistic of 12,862.390 (df= 21, p= 0.004).

Students were questioned to answer to items reflecting their classroom engagement, such as: (i) “I focused when my math instructor was talking,” (ii) I work hard to finish my home assignments of Mathematics and (iii) “I revised my Mathematic lessons in home among others. Five-point Likert scale was used to record students’ responses with key options; (i) Rarely, (ii) “occasionally” (iii) “half of the lessons,” (iv) “most of the time,” to (v) “always.”

Table 2 shows the validity assessment indicators and factor values for SMA. Reliability coefficient for the four-indicator measure is 0.81, however the KMO statisticfor sampling adequacy is 0.767, demonstrating strong construct validity. Standardized factor loadings ranges from 0.81 and 0.87, Strengtheningt he Evidence-based validityof the latent factor.



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**Student Math Attitude Measuring Indicators**

Attitude towards math in students was measured in terms of five indicators (SMA1-SMA5) on a five-point Likert scale. These are represented in Figure 5 in a line chart with the average values ranging between 2.04 and 4.24, standard deviations of 0.97 to 1.29, and factor loadings always at

0.78 to 0.88. The chart shows that the attitudes towards SMA3 (mean = 4.24) are positive with low ones on SMA2 (mean = 2.07) and SMA5 (mean = 2.04), which is a potential area of math anxiety or lack of interest.

The values are presented in Table 2: SMA1 (3.59, SD = 1.27, loading = 0.78), SMA2 (2.07, SD

=1.29, loading = 0.82), SMA3 (4.24, SD = 0.97, loading = 0.78), SMA4 (3.79, SD = 1.16, loading

= 0.88), and SMA5 (3.54, SD = 1.21, loading = It is reported in Table 3 that the value of reliability coefficient of four-indicator measure (a subgroup or error in labeling) is 0.81 with KMO = 0.767 and factor loading ranged between 0.81 and 0.87. All in all, Cronbach alpha = 0.809, KMO = 0.764 and Bartlett were significant (statistic = 11, 799.500, df = 15, p = 0.001), which confirms the validity of the construct.

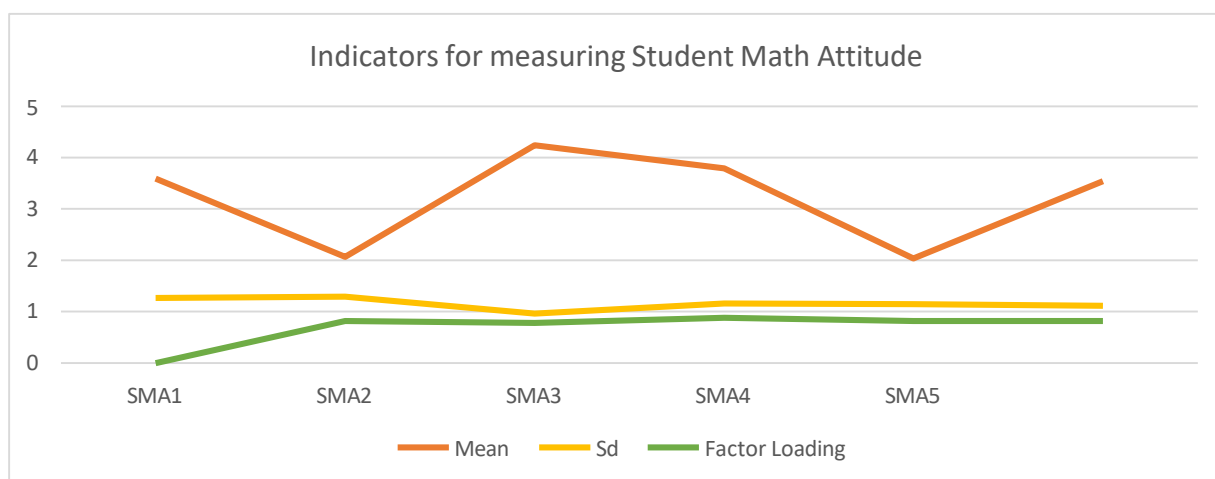


Fig:5 Indicators for measuring Student Math Attitude

Table 3

Indicators for measuring Student Math Attitude

Statement	Mean	SD	Factor Loading
SMA1	3.59	1.27	0.78
SMA2	2.07	1.29	0.82
SMA3	4.24	0.97	0.78
SMA4	3.79	1.16	0.88
SMA5	2.04	1.15	0.82



**Results of Structural Equation Model**

The mediation analysis was done to examine whether IBP and SMP relate through SMA using SEM. The path diagram is shown in Figure 6, where the beta coefficients are standardized (Std.  $\beta$ )

and the p-values and z-statistics are available. The significant paths are IBP to SMA (0.404,  $p < 0.001$ ,  $z = 3$ ), SMA to SMP (0.051,  $p < 0.001$ ,  $z = 2.3$ ), direct IBP to SMP (0.063,  $p < 0.001$ ,  $z = 3$ ) and indirect IBP to SMP through SMA (0.009,  $p < 0.001$ ,  $z = 2.2$ ).

These are summed up in Table 3 by direct effect and indirect effect. Direct effects: IBP  $\rightarrow$  SMA (Std.  $\beta = 0.404$ ,  $p = 0.001$ ,  $z = 3.00$ , 95% CI: 0.3740.41); SMA  $\rightarrow$  SMP (Std.  $\beta = 0.051$ ,  $p = 0.001$ ,  $z = 2.30$ , 95% CI: 0.0106); IBP  $\rightarrow$  SMP (Std.  $\beta = 0.063$ ,  $p < 0.001$ ,  $z = 2.20$ , 95 percent interval: 0.00 -0.02). The fit of the model was satisfactory: 0.94: 0.048: 0.054.

The high indirect effect supports the fact that IBP has a positive impact on SMP, both directly and through improvement of attitudes. Nonetheless, the insignificant effects indicate that other factors like socioeconomic status might moderate the effects. These results are based on theoretical frameworks such as expectancy-value theory, in which positive attitudes mediate pedagogy and achievement. In a practical sense, teachers in comparable cohorts ought to focus on IBP to enhance the involvement and achievement, but further investigation may be conducted to understand the long-term impacts or interventions when comparing cities with rural areas.

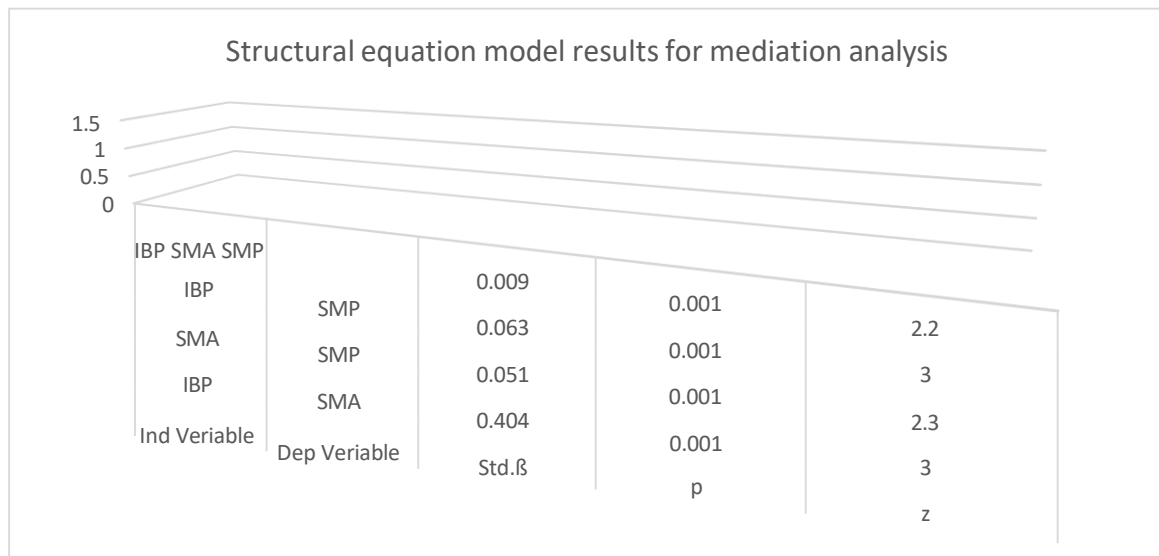


Fig 6 Structural equation model results for mediation analysis

Table 4  
Structural equation model results for mediation analysis

Independent Variable	Dependent Variable	Std. $\beta$	p	z	95%_Confidence_Interval
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Direct Effect					
IBP	SMA	0.404	<0.001	3.00	0.37-0.41
SMA	SMP	0.051	<0.001	2.30	0.01-0.06
IBP	SMP	0.063	<0.001	3.0	0.02-0.07
Indirect effect					
IBP → SMA → SMP		0.009	<0.001	2.20	0.00-0.02

**Direct Effects**

Inquiry-Based Pedagogy show a strong effect on Student\_Math\_Attitude (std.  $\beta = 0.404$ ,  $p < 0.001$ ), demonstrating that implementing inquiry-based teaching methods significantly enhances students' attitudes toward mathematics. Students' math attitude has a moderate but significantly positive impact on SMP (std.  $\beta = 0.051$ ,  $p < 0.001$ ), signifying that learners who exhibit confidence in math Generally achieve higher scores. IBP has a direct positive effect on SMP (std.  $\beta = 0.063$ ,  $p < 0.001$ ), showing that incorporating IBP can enhance students' math performance even without attitude mediation

**Indirect Effects**

The mediated effect of inquiry-based pedagogy on student's math performance via student's mathematical attitude is statistically significant. The indirect effect of IBP on SMP through SMA is significant but smaller (std.  $\beta = 0.009$ ,  $p < 0.001$ ), signifying that while math attitude mediates this relationship, its contribution is relatively modest. The proportion of the indirect effect accounts for 14.28% (0.009/0.063) of the direct effect or 15.25% (0.009/0.059) of the total effect, reinforcing the importance of improving math attitudes as a secondary mechanism in improving learner achievement.

**Discussion**

The results of findings of this research study confirm that IBP significantly enhances SMA and SMP. The strong direct effect of Inquiry based pedagogy on students' mathematic performance (std.  $\beta = 0.404$ ,  $p < 0.001$ ) suggests that engaging students through inquiry-driven learning fosters a more positive perception of mathematics, reinforcing findings from previous research that emphasize the role of student-cantered instructional approaches in shaping attitudes toward learning (Chiriacescu et al., 2023).

Similarly, SMA has significant moderate effect on SMP (std.  $\beta = 0.051$ ,  $p < 0.001$ ), indicating that students who develop a positive outlook on mathematics tend to perform better academically. (Berger et al., 2020) study findings align with this research study and also findings of (Ma & Kishor, 1997) are similar, which highlight the important key role of students' attitude responsible for academic success. A positive attitude towards mathematics motivates students to participate more actively in learning, build persistence, and use problem-solving strategies effectively (Bakker, 2019).

In addition, the immediate impact of IBP on SMP (std.  $\beta = 0.063$ ,  $p < 0.001$ ) confirms that IBP improves students' math performance independently of attitude mediation. This supports metacognition theory, which argues that learners in inquiry environments enhance better Thinking and reflective strategies, resulting in improved learning outcomes (Li & Yuan, 2022). These findings reinforce the idea that innovative teaching methods improve not only



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student engagement but also conceptual understanding, which is crucial for academic success (Grondin, 2018; Musa, 2022).

### **The Mediating Role of Math Attitude**

While SMA plays a role in the relationship between IBP and SMP, its contribution remains relatively modest, as indicated by the small but significant indirect effect (std.  $\beta = 0.009$ ,  $p < 0.001$ ). It indicates that although a positive attitude toward math contributes to better performance, the direct instructional impact of IBP remains more substantial. The results of this study is consistent with previous studies, which emphasize motivation and engagement are important, the quality of instruction remains a key driver of student achievement (Callaghan et al., 2018).

### **Contextual Considerations and Policy Implications**

Despite the overall effectiveness of IBP, regional disparities in educational outcomes must be considered. According to (Li & Yuan, 2022) findings of study shown that learners in public schools of urban areas tend to perform better than those in rural areas and private schools, largely due to differences in access to educational recourses, professional development of teachers, exposure to conducive learning setting. To overcome these problems, policymakers should provide equitable distribution learning material, improve teachers' training programs in resource-poor regions, and enhance availability of effective educational materials or AV aids facilitate learning.

Furthermore, inquiry-based pedagogy has the ability to minimize instructional differences by encouraging critical thinking and problem-solving skills within various student groups (Uche, 2015). According to research conducted by (Mulligan et al., 2020), effective pedagogy can actually minimize educational inequalities significantly. Instituting IBP as a baseline teaching method, in addition to targeted interventions, may facilitate greater accessibility and ease of academic design (Thompson, 2008).

### **Conclusion**

This study highlights the importance of inquiry-based pedagogy in developing students mathematical viewpoints and enhancing their academic achievement. Although Student math attitude moderately influences the relationship between inquiry-based pedagogy and student math performance, direct effects of IBP continue to be prevalent, affirming the necessity of student focused, inquiry-based learning strategies. Supporting teachers' uptake of IBP through formal training programs (Callaghan et al., 2018) and removing structural impediments to its enactment (Li & Yuan, 2022) can boost math learning outcomes on an expanded level. Future studies should examine other mediators like the self-efficacy of students, classroom participation, and teaching quality to further inform a broad understanding of the determinants of learners' math achievement

### **Ethical Approval**

This article does not contain any study with human participations performed by any of the authors.

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### Statements Questionnaire

Code	Statement	Code	Statement
<b>IBP1</b>	The teacher taught us to memorize rules and apply them to solve mathematics problems.	<b>IBP1</b>	The teacher taught us to memorize rules and apply them to solve mathematics problems.
<b>IBP2</b>	The teacher encouraged us to think about how to solve mathematics problems in different ways than demonstrated in class.	<b>IBP2</b>	The teacher encouraged us to think about how to solve mathematics problems in different ways than demonstrated in class.



<b>IBP3</b>	The teacher asked us to think about how new and old mathematics topics were related.	<b>IBP3</b>	The teacher asked us to think about how new and old mathematics topics were related.
<b>IBP4</b>	The teacher asked us to defend our answer to a mathematics problem.	<b>IBP4</b>	The teacher asked us to defend our answer to a mathematics problem.
<b>IBP5</b>	The teacher asked us to explain our reasoning when solving a mathematics problem.	<b>IBP5</b>	The teacher asked us to explain our reasoning when solving a mathematics problem.
<b>IBP6</b>	The teacher asked us to explain how we solved a mathematics problem.	<b>IBP6</b>	The teacher asked us to explain how we solved a mathematics problem.
<b>IBP7</b>	The teacher asked us to solve mathematics problems without computing anything.		