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Instructional and assessment factors shaping students' mathematics interest in secondary education

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ABSTRACT

Students' engagement in mathematics remains a persistent challenge in secondary education, particularly because students may respond differently across mathematical domains such as algebra, geometry, and statistics. However, previous studies often examine mathematics interest as a general construct, providing limited understanding of how instructional and assessment experiences influence domain-specific preferences. This study aimed to examine the influence of instructional and assessment factors on students' preferences across mathematical domains in secondary education. A quantitative explanatory design was employed involving 464 secondary students in East Java, Indonesia. Data were collected through a structured questionnaire and analyzed using multinomial logistic regression. The findings revealed that statistics was the most preferred mathematics domain, followed by algebra and geometry. The regression analysis showed that preferred instructional representation and preferred examination method significantly influenced students' mathematics domain preferences. These findings indicate that the way mathematical concepts are presented and assessed contributes to differences in students' engagement across mathematical domains. The study highlights that mathematics interest is domain-specific and pedagogically influenced rather than uniformly constructed. The findings imply that mathematics instruction should adopt more domain-responsive approaches by aligning instructional representation and assessment practices with the cognitive characteristics of different mathematical domains to improve student engagement in mathematics learning.

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1. INTRODUCTION

Students' declining interest in mathematics remains a major challenge in secondary education [1]. Although mathematics plays an essential role in developing scientific literacy, problem-solving skills, and technological competence, many students experience low motivation, limited engagement, and increasing anxiety toward the subject [2]–[4]. International assessments such as the Organization for Economic Co-operation and Development (OECD) Programme for International Student Assessment (PISA) consistently report that students' enjoyment, confidence, and perceived usefulness of mathematics are closely associated with academic achievement [5]–[7]. These findings indicate that improving mathematics learning

outcomes requires attention not only to cognitive performance but also to students' interest and engagement in learning mathematics. However, students' engagement with mathematics is often not uniform across all mathematical domains. Some students may feel more comfortable with visual and spatial reasoning tasks, while others may respond more positively to contextual interpretation or symbolic problem-solving [8], [9]. This suggests that mathematics interest may develop differently across mathematical domains depending on students' learning experiences and instructional exposure. At the secondary level, mathematics is taught through several domains, including algebra, geometry, and statistics. Algebra, geometry, and statistics involve different forms of mathematical reasoning and representation. Algebra is generally associated with symbolic and procedural reasoning [10], geometry emphasizes visual and spatial understanding [11], while statistics is closely related to contextual interpretation and data analysis [12]. Because each domain requires different forms of reasoning and representation, students may develop different levels of interest across mathematical strands. Some students may respond more positively to visual learning activities, whereas others may prefer structured explanation or contextual problem-solving tasks. Therefore, mathematics engagement should not be viewed as a single homogeneous construct, but rather as a domain-sensitive learning experience shaped by the interaction between students and classroom learning environments.

Previous studies have shown that instructional practices may contribute to students' motivation and engagement in mathematics learning [13], [14]. Multimedia learning, digital tools, and interactive instructional strategies have been associated with improved engagement, particularly in domains involving visualization and contextual representation [15]–[17]. Similarly, contextualized learning activities and applied assessment formats may help students perceive mathematics as more meaningful and relevant to everyday situations. In contrast, structured explanation and guided practice are often considered supportive for procedural and symbolic tasks such as algebra. Research has also demonstrated that students' affective responses toward mathematics may vary across mathematical domains [18]–[20]. These findings suggest that students' experiences in mathematics are influenced not only by individual factors but also by classroom instructional and assessment practices. Nevertheless, empirical findings across studies remain context-dependent, and many previous studies continue to focus primarily on general mathematics motivation rather than examining how instructional and assessment practices relate to students' preference across specific mathematical domains such as algebra, geometry, and statistics [9], [21], [22].

Although earlier studies acknowledged topic-based differences in mathematics engagement, domain-specific analysis remains relatively limited in contemporary mathematics education research [23], [24]. This issue is also important for supporting diverse student potential in mathematics education. Students whose strengths are related to visual reasoning may engage more effectively in geometry, while students who prefer contextual and applied learning activities may show greater interest in statistics. Without appropriate instructional support, students may gradually disengage from mathematics despite having strong potential in particular domains [25], [26]. In addition, classroom assessment practices may also influence how students perceive mathematical learning. Assessment is not merely a tool for measuring achievement, but also part of the learning experience that may shape students' confidence, participation, and engagement. Therefore, understanding domain-specific mathematics interest is important for developing more responsive and student-centered instructional strategies in secondary education. From a motivational perspective, expectancy–value theory explains that students are more likely to engage with learning domains they perceive as understandable, meaningful, and valuable [27], [28]. Similarly, self-determination theory emphasizes that students' engagement develops through perceived competence, autonomy, and supportive learning environments [29], [30]. Within mathematics education, these perspectives suggest that students' preference toward particular mathematical domains may emerge through continuous interaction between classroom experiences and the representational characteristics of mathematical content. Consequently, instructional alignment between learning approaches and mathematical domain characteristics becomes an important educational consideration.

Based on these considerations, this study examines how instructional and assessment factors relate to students' preferences across algebra, geometry, and statistics in secondary education. The study applies multinomial logistic regression to explore whether classroom instructional experiences, learning preferences, and assessment practices are associated with variation in students' mathematics domain preference. Unlike previous studies that examine mathematics motivation as a general construct, this study models domain-specific mathematics preference using multinomial logistic regression across algebra, geometry, and statistics. This study contributes to mathematics education research in several ways. First, it provides empirical evidence that students' mathematics engagement differs across domains and may be associated with classroom instructional experiences. Second, the study applies multinomial logistic regression to examine the relationship between instructional factors and domain preference. Third, the findings provide practical implications for developing more domain-responsive and student-centered mathematics instruction, particularly in secondary education contexts where maintaining student engagement remains a significant educational challenge.

2. CONCEPTUAL FRAMEWORK

The conceptual framework of this study explains how instructional experiences and assessment practices may relate to students' preference toward different mathematical domains in secondary education. This study views mathematics engagement as a learning experience shaped by interaction between students and classroom instructional environments across different mathematical domains. As illustrated in Figure 1, the framework integrates three interrelated perspectives: student-centered learning, instructional and assessment ecology, and motivational theory. These components interact through classroom experiences and may contribute to variation in students' preference toward mathematical domains such as geometry, statistics, and algebra. Previous studies have suggested that supportive instructional environments, meaningful learning experiences, and responsive assessment practices may contribute positively to students' engagement and participation in mathematics learning [31]–[33]. However, the influence of instructional experiences may not be identical across mathematical domains because each domain possesses different representational and cognitive characteristics. Therefore, the present framework emphasizes the importance of understanding mathematics engagement within a domain-specific educational context.

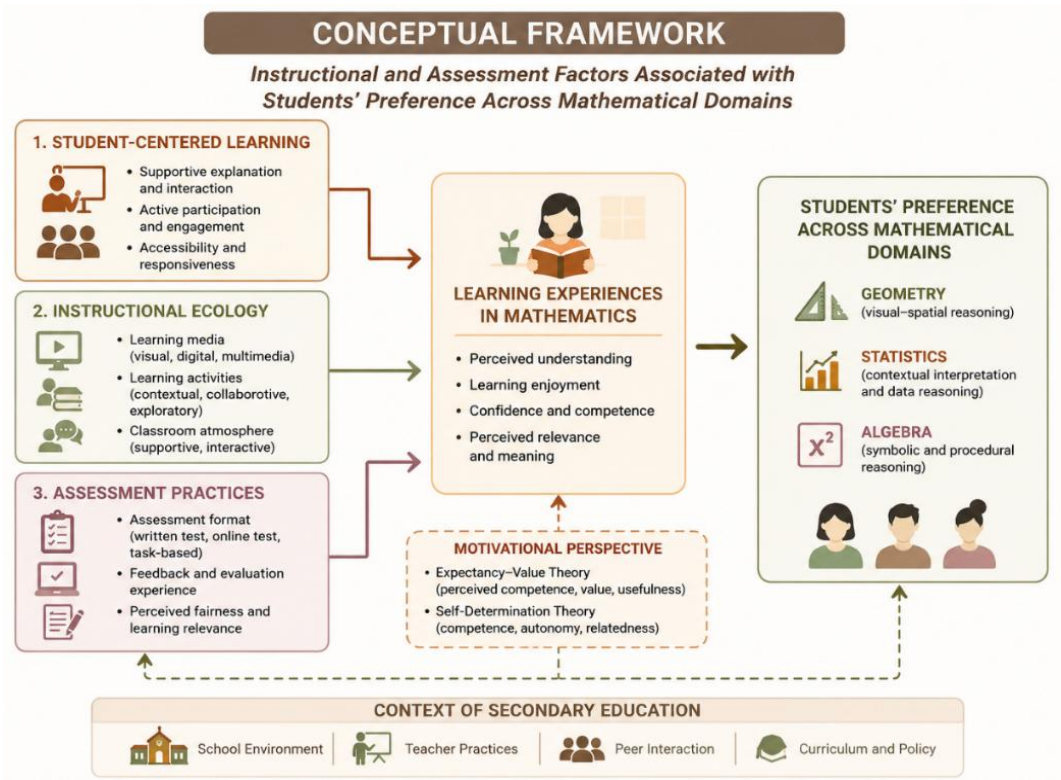


Figure 1. Conceptual framework

2.1. Student-centered learning and mathematics engagement

Student-centered learning emphasizes active participation, accessibility, and responsiveness to students' learning needs. In mathematics education, instructional approaches that encourage interaction, conceptual accessibility, and representational variation may help students engage more meaningfully with mathematical concepts [15], [29], [34]. Clear explanation, supportive classroom interaction, and opportunities for independent exploration may also contribute to students' confidence and learning involvement. Within this perspective, students' engagement with mathematics may develop differently across mathematical domains. Geometry, for example, often relies on spatial reasoning and visual representation, while statistics is more closely connected to contextual interpretation and data-oriented thinking. Algebra, in contrast, frequently requires symbolic manipulation and procedural reasoning. Consequently, students may respond differently to instructional explanation, learning media, and classroom interaction depending on the characteristics of the mathematical domain being learned. Student-centered learning therefore becomes important not only for improving participation, but also for supporting domain-sensitive engagement in mathematics learning.

2.2. Instructional and assessment ecology

This study also considers instructional and assessment ecology as an important component influencing students' mathematics learning experiences. Classroom instructional experiences include explanation methods, learning media, learning activities, and assessment practices that shape students' interaction with mathematical content. Previous studies have indicated that multimedia learning environments, contextual learning experiences, and interactive instructional approaches may support students' understanding and participation in mathematics learning [16], [35]. Nevertheless, the contribution of these instructional experiences may vary across mathematical domains. Visual explanation and multimedia representation may help students access concepts involving spatial visualization or contextual interpretation, whereas structured explanation and guided examples may be perceived as more supportive for symbolic and procedural reasoning. Similarly, assessment practices may also influence how students perceive mathematical learning. Forms of evaluation such as written examinations, online assessment, or task-based activities may shape students' comfort, participation, and motivational orientation toward specific mathematical domains. Therefore, instructional and assessment experiences are viewed not as universal determinants of mathematics engagement, but as contextual factors that may contribute differently across mathematical strands.

2.3. Motivational perspective in mathematics learning

The conceptual framework of this study is also informed by motivational perspectives, particularly expectancy–value theory and self-determination theory. Expectancy–value theory explains that students are more likely to engage with learning domains they perceive as understandable, meaningful, and valuable [28], [30]. Within mathematics education, students may develop stronger preference toward mathematical domains that align with their perceived competence and learning experiences. Similarly, self-determination theory emphasizes that students' engagement develops through perceived competence, autonomy, and supportive learning environments [30]. When students experience instructional approaches that help them feel more capable of understanding mathematical concepts, they may demonstrate stronger engagement and participation. In this context, students' preference toward particular mathematical domains may emerge through continuous interaction between instructional experience, assessment practices, and the representational demands of mathematical content. This study assumes that students may respond differently across mathematical domains depending on classroom instructional and assessment experiences. Different mathematical domains may activate different forms of perceived competence, accessibility, and learning comfort depending on how instructional experiences are organized within the classroom.

2.4. Analytical framework

Based on this framework, the study assumes that instructional preferences, learning experiences, and assessment practices may be associated with variation in students' preference toward geometry, statistics, and algebra. To examine these relationships, multinomial logistic regression was employed as an explanatory analytical approach to explore how classroom instructional and assessment experiences relate to students' mathematics domain preference [36], [37]. Rather than functioning solely as a predictive mechanism, the multinomial regression model is positioned as an interpretive educational tool that helps explain domain-sensitive patterns of mathematics engagement. Through this approach, the study seeks to identify how different instructional and assessment experiences may contribute to students' orientation toward particular mathematical domains within secondary education.

3. METHOD

3.1. Research design

This study employed a quantitative explanatory research design to examine how instructional and assessment factors are associated with students' preferences across mathematical domains in secondary education. The study focused on three mathematics domains: algebra, geometry, and statistics. A quantitative approach was selected because the research aimed to investigate the relationship between classroom instructional experiences and students' mathematics domain preferences using statistical modeling. The study adopted a cross-sectional survey design in which data were collected at a single point in time through structured questionnaires administered to students. Multinomial logistic regression was used as the primary analytical approach because the dependent variable consisted of more than two categorical outcomes representing students' preferred mathematics domains.

3.2. Research participants

The research was conducted in several junior and senior secondary schools (SMP and SMA) in East Java, Indonesia. A total of 464 students participated in the study. Participants were selected using purposive

sampling based on two inclusion criteria: i) students were actively enrolled in mathematics courses during the data collection period and ii) students completed all questionnaire items required for analysis. The sample consisted of students from both junior and senior secondary education levels to capture variation in mathematics learning experiences across secondary education contexts. The use of purposive sampling was intended to ensure that participants had sufficient exposure to classroom instructional and assessment practices relevant to the objectives of the study.

Table 1 presents the demographic distribution of the participants included in this study. The demographic distribution indicates that most participants were senior secondary students and were enrolled in private schools. This distribution reflects the accessibility of participating schools during the data collection process and provides contextual representation of mathematics learning experiences within secondary education settings in East Java.

Table 1. Distribution of participant demographics

Variable	Category	Frequency (n)	Percentage (%)
Grade level	Junior secondary (SMP)	63	13.57
	Senior secondary (SMA)	401	86.43
School type	Public school	49	10.56
	Private school	415	89.44
	Total	464	100.00

3.3. Research instrument

Data were collected using a structured questionnaire designed to measure students' mathematics domain preferences and instructional experiences in mathematics learning. The dependent variable represented students' preferred mathematics domain, categorized into algebra, geometry, and statistics. The independent variables included students' perceptions related to: i) teacher explanation methods; ii) frequency of internet-supported learning; iii) instructional representation and learning media; iv) classroom learning preferences; v) assessment formats; and vi) learning strategies for understanding mathematical concepts.

The questionnaire items were developed based on student-centered learning principles and previous studies related to mathematics engagement and instructional practices in secondary education. The items were designed to capture observable classroom experiences rather than abstract psychological constructs in order to maintain contextual relevance and clarity. Several variables were operationalized as single-item indicators representing specific instructional experiences, such as multimedia-supported explanation, structured example-based instruction, visual representation, and contextual assessment.

This approach was intended to reduce respondent burden while maintaining direct correspondence between questionnaire items and classroom practices. Prior to the main study, the instrument underwent content validation involving two mathematics education experts and one educational measurement specialist to evaluate item relevance, clarity, and alignment with the research objectives. A pilot test involving 30 students outside the primary sample was also conducted to assess item readability and response consistency. Based on the pilot evaluation, minor revisions were made to improve wording clarity and response interpretation.

3.4. Data collection procedure

Data collection was conducted during regular classroom sessions after obtaining permission from participating schools. Students were informed about the purpose of the research and participated voluntarily. To maintain confidentiality, no identifying personal information was collected during the survey process. The questionnaires were administered directly in classroom settings under researcher supervision to ensure consistency in instructions and response procedures. Following data collection, all responses were reviewed to ensure completeness and consistency. Only fully completed questionnaires were included in the final analysis.

3.5. Data analysis

The data were analyzed using multinomial logistic regression to examine how instructional and assessment factors relate to students' preferences across mathematics domains [36], [37]. This analytical approach was selected because the dependent variable consisted of three nominal categories representing students' preferred mathematics domains. In the regression model, geometry was used as the reference category. The analysis estimated the relative likelihood of students preferring statistics or algebra compared with geometry based on instructional and assessment experiences reported in the questionnaire. Descriptive statistics were initially used to summarize participant characteristics and response distributions.

Subsequently, multinomial logistic regression analysis was conducted to estimate regression coefficients, odds ratios (OR), confidence intervals, and significance values for each predictor variable.

To evaluate model adequacy, several diagnostic procedures were conducted, including model fitting evaluation, goodness-of-fit assessment, and pseudo R-square examination [37], [38]. In addition, multicollinearity among predictor variables was assessed to ensure coefficient stability. The independence of irrelevant alternatives (IIA) assumption was also considered to support the appropriateness of multinomial logistic regression for categorical outcome analysis.

3.6. Ethical Considerations

This study adhered to ethical principles for educational research involving human participants. Institutional permission was obtained from participating schools before data collection. Participation was voluntary, and students were informed that their responses would be used solely for academic purposes. All responses were collected anonymously and analyzed only at the group level to maintain confidentiality. The study did not evaluate or rank individual students, and the analytical model was used exclusively to examine patterns of instructional influence on mathematics domain preferences.

4. RESULTS AND DISCUSSION

4.1. Distribution of students' mathematics domain preferences

The descriptive analysis indicates that students' preferences toward mathematics vary across mathematical domains. Among the 464 participants, statistics was the most preferred domain, followed by algebra and geometry; Table 2 shows the detail of this number. These findings suggest that students' mathematics engagement is domain-specific rather than uniformly distributed across all mathematical strands.

The high preference for statistics may indicate that students respond positively to mathematical activities involving contextual interpretation and real-world application. In contrast, geometry showed the lowest level of preference, suggesting that spatial and visual reasoning tasks may require more supportive instructional approaches to maintain engagement. These findings support the view that students experience mathematics differently depending on the representational and cognitive characteristics of each domain.

Table 2. Distribution of students' mathematics domain preferences

Mathematics domain	Frequency (n)	Percentage (%)
Geometry	82	17.7
Statistics	253	54.5
Algebra	129	27.8
Total	464	100

4.2. Model fitting and goodness-of-fit evaluation

Prior to interpreting the regression coefficients, several diagnostic analyses were conducted to evaluate the adequacy of the multinomial logistic regression model. The likelihood ratio test, as shown in Table 3, present the final model significantly improved prediction performance compared with the intercept-only model (χ^2=71.289, p=0.006). This result indicates that instructional and assessment variables collectively contributed to explaining students' mathematics domain preferences. Goodness-of-fit evaluation was also conducted using Pearson and deviance statistics, as shown in Table 4.

Table 3. Model fitting information

Model	-2 log likelihood	Chi-square	df	Sig.
Intercept only	869.960	-	-	-
Final	798.671	71.289	44	0.006

Table 4. Goodness-of-fit statistics

Test	Chi-square	df	Sig.
Pearson	818.841	766	0.091
Deviance	753.368	766	0.621

Both goodness-of-fit statistics produced non-significant values ($p>0.05$), indicating acceptable agreement between observed and predicted values. This suggests that the multinomial logistic regression model demonstrated satisfactory fit with the observed data. The explanatory contribution of the model was further evaluated using pseudo R-square measures. Table 5 shows the Nagelkerke value indicates that the instructional and assessment variables explained approximately 16.5% of the variation in students' mathematics domain preferences. Although the explanatory power is moderate, such values are considered acceptable in educational research where learning engagement is influenced by multiple contextual and individual factors.

Table 5. Pseudo R-square values

Measure	Value
Cox and Snell	0.142
Nagelkerke	0.165
McFadden	0.077

4.3. Significant predictors of mathematics domain preference

Likelihood ratio tests were conducted to identify instructional and assessment variables that significantly contributed to the multinomial regression model. The likelihood ratio test indicates that only two variables significantly contributed to the multinomial regression model: preferred instructional representation and preferred examination method. These findings suggest that the way mathematical concepts are presented and assessed plays an important role in shaping students' preferences across mathematics domains. The results from Table 6 indicate that instructional and assessment experiences are associated with variation in students' engagement across algebra, geometry, and statistics. This suggests that classroom learning experiences may influence domain preference. Different instructional approaches may also support engagement differently across mathematical domains.

Table 6. Significant predictors of mathematics domain preference

Variable	Chi-square	df	Sig.
Preferred instructional representation (X3)	11.814	4	0.019*
Preferred examination method (X9)	18.053	4	0.001*

*Significant at $p<0.05$

4.4. Discussion

The findings of this study demonstrate that students' mathematics engagement is domain-specific and influenced by instructional as well as assessment experiences. The descriptive results showed that statistics emerged as the most preferred mathematics domain, followed by algebra and geometry. This pattern suggests that students do not experience mathematics as a uniform subject, but rather respond differently to domains according to the representational characteristics and learning demands of each mathematical strand [29], [39].

The high preference toward statistics may be associated with the contextual and applied nature of statistical learning. Statistics frequently involves interpretation of real-world situations, data representation, and contextual reasoning, which may increase students' perception of relevance and usefulness. This finding aligns with expectancy–value theory, which explains that students are more likely to engage with learning domains they perceive as meaningful, useful, and valuable. When students can connect mathematical concepts to authentic situations, they may develop stronger task value and learning engagement. In this context, contextual mathematical activities appear to strengthen students' willingness to participate in mathematics learning. In contrast, geometry showed the lowest level of preference among students. One possible explanation is that geometry requires spatial reasoning, visualization, and abstract representation, which may create additional cognitive demands for some learners. According to cognitive load theory, students may experience learning difficulty when instructional support is insufficient to manage complex visual and spatial information. This finding suggests that geometry instruction requires stronger visual scaffolding, representational support, and interactive learning media to help students construct conceptual understanding more effectively [28], [40], [41].

The multinomial regression analysis further demonstrated that preferred instructional representation significantly influenced students' mathematics domain preferences. This result indicates that the way mathematical concepts are delivered plays an important role in shaping students' engagement. Students who

prefer visual explanation, contextual representation, or structured examples may develop different orientations toward particular mathematical domains depending on how instruction aligns with their learning preferences. This finding supports multimedia learning perspectives suggesting that students learn more effectively when mathematical concepts are presented through clear visual and contextual representation [42]. In domains such as statistics and geometry, visual representation and contextual explanation may help reduce abstraction and improve conceptual accessibility. Meanwhile, algebra may benefit more strongly from structured and sequential explanation because algebraic reasoning relies heavily on symbolic manipulation and procedural understanding. The significance of examination method also highlights the important role of assessment practices in mathematics learning. Assessment is not merely an evaluation mechanism, but also part of the instructional environment that shapes students' perceptions of learning. Students may demonstrate stronger engagement when assessment formats align with their preferred ways of expressing understanding. This finding supports student-centered learning perspectives, which emphasize the importance of creating learning environments that accommodate students' cognitive and motivational differences [31], [41], [42].

Supportive instructional and assessment experiences may strengthen students' confidence and participation in mathematics learning. When students experience instructional approaches that help them understand mathematical concepts more clearly, they are more likely to develop confidence and sustained engagement. In contrast, instructional approaches that are perceived as inaccessible or overly abstract may reduce students' participation and motivation [33], [43]. Importantly, the findings suggest that instructional effectiveness in mathematics education is not universal across all domains. Different mathematical strands require different representational and pedagogical approaches. Statistics learning may benefit from contextualized datasets, real-world interpretation, and applied assessment tasks [12]. Geometry instruction may require visual representation, diagrams, and spatial learning support [11], while algebra may depend more strongly on guided procedural explanation and structured practice [10].

These findings carry important implications for secondary mathematics education. Uniform instructional strategies may unintentionally limit engagement among students whose strengths are domain-specific. Therefore, mathematics teachers should adopt more domain-responsive instructional approaches that align pedagogical strategies with the cognitive characteristics of different mathematical domains. Such alignment may help improve students' participation, engagement, and confidence in mathematics learning. This study demonstrates that students' mathematics preferences are shaped through interaction between instructional experiences, assessment practices, and the representational demands of mathematical content. Mathematics engagement should therefore be understood as context-dependent and pedagogically influenced rather than as a fixed individual characteristic.

5. CONCLUSION

This study demonstrates that students' mathematics preferences differ across mathematical domains and are influenced by instructional as well as assessment experiences in classroom learning. Among the three domains examined, statistics emerged as the most preferred domain, followed by algebra and geometry, indicating that students' engagement with mathematics is domain-specific rather than uniformly distributed. The multinomial logistic regression analysis showed that preferred instructional representation and preferred examination method significantly influenced students' mathematics domain preferences. These findings suggest that the way mathematical concepts are presented and assessed plays an important role in shaping students' engagement across different mathematical domains.

The study contributes to mathematics education research by showing that students' mathematics engagement is influenced by classroom instructional and assessment experiences. Unlike previous studies that treat mathematics interest as a general construct, this study highlights the importance of domain-responsive instructional approaches in supporting students' engagement with algebra, geometry, and statistics. From an educational perspective, the findings imply that mathematics instruction should consider the representational and cognitive characteristics of different mathematical domains. Contextual and applied learning activities may strengthen engagement in statistics, while structured explanation and visual representation may support learning in algebra and geometry.

Therefore, aligning instructional and assessment practices with students' learning preferences may help improve participation and engagement in mathematics learning. This study is limited by its cross-sectional design and reliance on self-reported questionnaire data, which may not fully capture changes in students' engagement over time. Future research may examine domain-specific mathematics engagement using longitudinal data and more diverse educational settings.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

All authors declare that they have no conflicts of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies and has been approved by the authors' institutional review board or equivalent committee.

DATA AVAILABILITY

The data that support the findings of this study are available on request from the corresponding author, [RKP]. The data, which contain information that could compromise the privacy of research participants, are not publicly available due to certain restrictions.

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