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Examining the Mediating Role of Students' Perception of Mathematics in the Relationship between Teacher Positioning and Mathematics Identity Among Senior High School Students

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ABSTRACT

Mathematics learning involves not only acquiring mathematical concepts and skills but also developing an identity as a member of the mathematics classroom community. This study examined the relationship between teacher positioning and student mathematics identity and the mediating effect of students' perceptions of mathematics. A survey was conducted among 508 senior high school students, and the research instrument was pilot-tested and validated on 340 students and 238 teachers. Structural equation modeling and mediation analysis were used to analyze the data. The findings revealed that teacher positioning had a direct impact on students' mathematics identity even when students' perception of mathematics was considered a mediator variable. Mediation analysis showed that students' perception of mathematics partially mediated the relationship between teacher positioning and students' mathematics identity, confirming that teacher positioning and students' perceptions of mathematics are crucial components in the construction of students' mathematics identity. This research demonstrates the role of teacher positioning and students' perceptions of mathematics and highlights factors that contribute to the development of mathematics identity and their interactions with teacher positioning and students' mathematics perception. Further research should investigate other factors that contribute to mathematics identity and their impact on student learning outcomes.

Keywords: ***experience, identity construction, math teaching, position and role***

Introduction

The acquisition of mathematical knowledge and skills is essential in preparing young individuals for success in modern society (OECD, 2019). However, fostering positive dispositions toward mathematics is crucial in addition to mastering these concepts. This includes students' beliefs about their mathematical abilities and mindsets regarding intelligence, as research has shown that these factors significantly impact academic achievement (Dweck, 1986). Developing a strong mathematical identity and positive relationships with peers and subject matter also plays a crucial role in students' engagement with mathematics practices and, ultimately, their academic success (Cobb et al., 2009). Furthermore, students' self-concept beliefs have been shown to influence their effort and perseverance in the face of challenges, making them critical for student motivation and learning (Dweck, 2006).

Developing a strong student mathematics identity is a critical component of learning mathematics in schools (Allen & Schnell, 2016). This identity is shaped by students' views of themselves in relation to mathematics and how they are viewed within the mathematics community. Therefore, it is important for mathematics learners to not only focus on mastering mathematical concepts and skills but also develop their identity as mathematics learners (Anderson, 2007; Heller, 2015). This emphasizes the significance of developing a sense of belonging and membership within the mathematics classroom community, known as a student's mathematics identity, which is crucial for successful learning (Alexander, 2015).

In a classroom community, interactions between teachers and students play a crucial role in the development of students' identities. How teachers position themselves and their students is of great importance in the development of students' mathematics identity (Yamakawa, 2014). "Through their positioning moves, teachers implicitly communicate rights, duties, and obligations associated with their position (Harré, 2012; Wood, 2013)."

Classroom interactions can significantly impact learning and identity formation, emphasizing the effects of both teachers' and students' actions and utterances on claiming and assigning identities (Norton, 2013). Thus, it is important to investigate how teachers position themselves and their students and how this influences student engagement (Hazari et al., 2015) by probing into the speech and storylines developed during interactions (Wagner & Herbel-Eisenmann, 2015).

Research on mathematics education shows that teacher positioning plays a critical role in shaping students' mathematics identity (Yamakawa, 2014), but other factors also contribute to this process. Since students' backgrounds and prior experiences in mathematics classrooms can vary, it is important to investigate how their perception of mathematics mediates the relationship between teacher positioning and student mathematics identity.

This study sought to explore the relationship between teacher positioning and student mathematics identity by closely examining the positions assigned by teachers and the effects of these positions on students' engagement in the classroom. Mediation analysis was employed to achieve this because it allowed a more comprehensive understanding of the relationship between teacher positioning and student mathematics identity. By examining the mediating role of students' perceptions of mathematics, this study likewise identified potential mechanisms through which teacher positioning affected student outcomes. This, in turn, can lead to targeted interventions aimed at improving students' mathematics identity and engagement. By exploring the direct and indirect effects of teacher positioning on students' mathematics identity, one can understand how teachers create classroom environments that foster positive mathematics identity. Furthermore, specific areas where teachers can intervene to promote positive mathematics identities among their students can be identified. This helps increase students' engagement and achievement in mathematics, which are crucial for their future success in STEM fields and beyond. This study answered the following research questions:

1. Does teacher positioning have a direct effect on students' mathematics identity?
2. Does students' perception of mathematics mediate the relationship between teacher positioning and their mathematics identity?

Teacher Positioning

Positioning helps explain students' participation in classroom discourse and their development as learners (Kayi-Aydar & Miller, 2018). According to Harré and van Langenhove (1999), positions are not freely constructed but emerge dynamically in social interactions. Positioning involves the joint action of conversation participants to locate each other in a storyline and assign positions within that conversation. In this context, teacher positioning refers to the deliberate actions and interactions within the classroom environment that influence the roles, perspectives, and engagement levels of students.

To examine classroom positioning, teachers' and students' conversations, perspectives, and the stories they produce within their interactions can be examined. Positioning theory highlights the dynamic and ever-changing nature of people and their contexts (Harré & Moghaddam, 2015). During initial positioning moves in interactions, individuals may not intend to position themselves in particular ways. However, once individuals are interactively assigned positions, they may attempt to refuse or challenge them and impose their own.

Positioning theory explains how positions and storylines constrain or facilitate the emergence of possible actions and meanings. It also sheds light on how rights, duties, and responsibilities are assigned relative to shared cultural repertoires, which shape individuals. Thus, positioning theory is a useful lens for investigating classroom interactions and their impact on learning and identity construction. This aligns well with sociocultural approaches, which emphasize that learning is mediated and developed through participation in social practices.

Student Mathematics Identity

The present study examines student mathematics identity from a relational and socio-cultural perspective. This perspective views identity as a dynamic phenomenon that emerges in local discourse contexts of interaction rather than as a fixed structure located primarily in the individual psyche or fixed social categories (Bucholtz & Hall, 2005). Recent identity research has emphasized the power of individual agency alongside the social negotiation of identity (Beauchamp & Thomas, 2009). This conceptualization of identity acknowledges that individuals construct, adapt, and reject identity positions for themselves despite external influences.

Sfard and Prusak (2005) defined identity as the interplay between engagement, imagination, alignment, and nature. Oppland-Cordell and Martin (2015), meanwhile, conceptualized identity based on Wenger's (1998) work on engagement, imagination, and alignment. In mathematics, Boaler and Selling (2017) defined mathematical identity as a set of ideas, beliefs, and behaviors that students performed in mathematics learning. Their definition also included students' ways of thinking about themselves and their commitment, engagement, and values.

This study builds on the interplay between core and normative identities to examine students' mathematics identity. Core identity refers to who people think they are (nature) and who they would like to be (imagination), whereas normative identity refers to who people think they need to become (engagement) to belong in a certain context (alignment). The interplay between these two identities produces personal identities that affect a person's actions. Additionally, this study considers the faces of identity - engagement, imagination, nature, and alignment - as important factors in the construction of students' mathematics identity (Anderson, 2007). By examining students' mathematics identity from this perspective, this study provides a deeper understanding of how identity influences students' learning experiences in mathematics.

Students' Perception of Mathematics

Students' mathematics perceptions and beliefs are shaped by past experiences that encompass both the cognitive and affective dimensions (Mutodi & Ngirande, 2014). According to Schoenfeld (2008), students' perception of mathematics is a critical factor influencing their approach to mathematics tasks, which in turn affects their engagement in the classroom. The traditional approach to teaching mathematics, which involves presenting theory, examples, practice exercises, and assessment, may lead students to believe that mathematics is a set of rules that requires quick, correct answers. This approach does not allow students to explore the different strategies and solutions to a problem or the various ways of defining mathematical concepts, which can limit their creativity and resourcefulness and hinder their confidence in mathematics.

A mathematics classroom is a social system in which students' mathematical identities are constructed and developed. Students' experiences in secondary school mathematics, in particular, can have a significant impact on their future learning experiences and identities (Hembree, 1990). The stories and narratives that students remember about how they were viewed by their teacher and peers and how they viewed their teacher can affect how they feel as learners (Edwards, 2010). As Grootenboer and Zevenbergen (2008) argued, the goal of mathematics education is to develop students' mathematics identity.

Klein (2000) noted that students made sense of their lives based on past discourses and present experiences. Boaler and Greeno (2000) demonstrated that inquiry-based pedagogy in mathematics could foster active and social engagement with the subject, potentially motivating students to pursue further study. Conversely, if students are only exposed to repetitive exercises without the chance to derive meaning independently, they may not perceive themselves as mathematics learners. It is crucial to note that teachers' approaches, task assignments, and classroom structures significantly shape students' mathematical identity (Hima et al., 2019). This emphasizes the relevance of students' perception of mathematics in understanding the relationship between teacher positioning and student mathematical identity.

When students develop their strategies and meanings to solve mathematics problems, and their ideas and explanations are accepted by their peers and teachers, they are more motivated to learn and view themselves as capable learners (Boaler & Greeno, 2000). Conversely, if students do not make sense of mathematics or connect with it at a personal level, or if they do not feel recognized as contributors to the mathematics classroom, they may not see themselves as capable learners. Harackiewicz et al. (2016) argued that when students saw how math was useful in real life, they were more likely to stick with it and do well. They also suggested that teachers could get students more interested by showing how math applied to the real world. In mathematics classes, students learn about themselves as mathematics learners through their interactions with teachers, parents, and classmates (Radovic et al., 2017). Since student identity is about how they see themselves and how others see them (Oppland-Cordell & Martin, 2015), their experiences and relationships in mathematics class are important for how they see themselves as math learners. Their study focuses on students' experiences and involvement in mathematics classrooms and their interactions with mathematics teachers and peers at previous grade levels.

Research has shown that teacher positioning, or the ways in which teachers interact with their students, influences students' attitudes and beliefs about mathematics (Boaler, 2002; Cai et al., 2018; Scott et al., 2006). Teachers who create a positive classroom culture and provide opportunities for student participation and engagement positively affect students' mathematics identity (Boaler, 2002; Cai et al., 2018). Conversely, teachers who focus on memorization and rote learning and who create a competitive classroom environment negatively impact students' mathematics identity (Boaler, 2002).

Students' perceptions of mathematics or their beliefs about and attitudes toward mathematics are also crucial in the development of their mathematics identity (Cobb et al., 2009). Students who view mathematics as relevant and meaningful are more likely to have a positive mathematics identity and be motivated to learn mathematics, whereas those who view mathematics as difficult, irrelevant, or boring are more likely to have a negative mathematics identity and be disengaged from learning mathematics (Cobb et al., 2009). Latterell and Wilson (2016) demonstrated that students' prior experiences with mathematics could influence their perception of mathematics, which in turn could impact their mathematics identity. Hazari et al. (2015) found that students' beliefs about their mathematics ability could also impact their engagement in mathematics practices and, ultimately, their mathematics identity.

Teacher positioning and students' perceptions of mathematics are important factors in the development of students' mathematics identity. However, further research needs to investigate the mediating effects of students' perception of mathematics on the relationship between teacher positioning and student mathematics identity. This can provide valuable insights into the complex interactions between these variables and inform the development of effective teaching practices that can promote the development of a positive mathematics identity in students.

Research in mathematics education highlights the important role of teacher positioning and student mathematics identity in shaping student outcomes in mathematics. Although still limited, studies have explored the mediating effects of students' perceptions of mathematics on the relationship between teacher positioning and students' mathematics identity. For example, Cai et al. (2018) found that students' perceptions of the relevance of mathematics to their lives mediated the relationship between teacher support and students' mathematics self-concept. This suggests that students' perception of mathematics is a mediator in the relationship between teacher positioning and their mathematics identity. Cai et al. (2017), meanwhile, found that teacher positioning, in terms of providing challenging tasks and promoting discourse, had a positive effect on students' mathematics identity and that this effect was partially mediated by students' perceptions of mathematics as a meaningful and relevant subject. Similarly, Grootenboer and Hemmings (2007) investigated teacher positioning in the form of providing opportunities for engagement and promoting positive attitudes toward mathematics. Teacher positioning had a positive effect on students' mathematics identity. This crucial effect was partially mediated by students' perceptions of the value of mathematics in their lives. Wong et al. (2019), meanwhile, demonstrated that teacher positioning and student mathematics identity were influenced by how students perceived their mathematical proficiency, illustrating the importance of being attentive to instructional methods and cognizant of the impact these methods have on students' self-perceptions in mathematics. Teachers should also strive to cultivate an environment that nurtures students' confidence in their mathematical abilities, as this can significantly shape their overall mathematics identity and academic performance. These studies indicate that students' perceptions of mathematics play an important mediating role in the relationship between teacher positioning and their mathematics identity.

METHODS

Design

The study employed a mixed-methods research design to explore the relationship among teacher positioning, students' perceptions of mathematics, and their mathematics identity. This approach combined quantitative data for statistical insights with qualitative data to capture nuanced perspectives. Integrating surveys and numerical assessments allowed the study to quantify relationships, identify patterns, and provide valuable insights into their strength and direction.

Participants

Five hundred eight senior high school students (208 males and 300 females) from 12 different classrooms participated in the study. The inclusion of students was based on their enrollment in the participating teachers' mathematics classes. Twelve teachers (two males and 10 females) were also invited to participate in the research. To be included in the study, teachers had to be currently teaching mathematics in senior high schools and agree to participate.

The participants were from ten public senior high schools, four of which were in Metro Manila and six in Region IVA-CALABARZON. These two regions were chosen to represent senior high schools in highly urbanized and rural areas. These schools share similarities in terms of curriculum, teaching methods, and professional development opportunities for teachers, as well as their high enrollment rates and diverse geographical locations. It is important to note that convenience sampling was used because of time constraints, which may limit the generalizability of the findings. The sample size of the study may also limit the power of the statistical analysis, especially for complex structural equation modeling.

Instruments

The researcher developed three instruments to measure the different aspects of the study's participants, guided by a table of specifications for each instrument and the related literature. Face, content, and construct validity testing were conducted, and the instruments were pilot-tested on a group of grade 11 students to ensure comprehensibility. Internal reliability testing was conducted using Cronbach's alpha coefficients (Raykov, 1997).

Research Instrument 1: Teacher Positioning Survey

The Teacher Positioning Survey is a questionnaire adapted from the work of Yamakawa (2014). It includes items that assess interactive and reflexive teacher positioning in the classroom. Reflexive positioning involves three categories: 1) validating, 2) interrupting, and 3) comparing. Interactive positioning examines how teachers position their students, considering them as independent learners, legitimate contributors to the discussion, dependent recipients of information, or responsible individuals. Respondents rate each item on a four-point Likert scale, ranging from "always" (4) to "never" (1). Higher scores indicate greater teacher positioning.

This survey, comprising 60 items, was piloted with 208 mathematics teachers in several senior high schools. Data analysis included screening for missing data and conducting exploratory factor analysis (Costelo & Osborne, 2005; Williams et al., 2010). The Kaiser-Meyer-Olkin (KMO) measured and Bartlett's test of sphericity confirmed the suitability of the data for factor analysis (Kaiser, 1974). Cronbach's alpha coefficient demonstrated high reliability (0.87). Subsequent analyses involved deleting items with factor loadings below 0.40 and refining the model through confirmatory analysis.

After modification, the final instrument demonstrated improved model fit indices, suggesting its efficacy in assessing teacher positioning in the classroom. These data will aid in understanding how teacher behaviors influence student engagement and learning outcomes, thus showing the relationship between teacher positioning and student mathematics identity. Table 1 shows the improved fit indices of the model.

Table 1

Fit Indices of the Final CFA Model for Teacher Positioning

Fit Indices	CMIN $\frac{x^2}{df}$	RMSEA	SRMR	GFI	CFI	TLI	IFI	EVCI
Value	216.99/169 [1.284] $p = .05$	0.035 $p = 0.98$	0.078	0.964	0.978	0.976	0.978	1.262

The final Confirmatory Factor Analysis (CFA) model for the Teacher Positioning Instrument (TPI) yielded positive results. The CMIN value was 1.284, below the upper boundary of 2, indicating a good fit. Additionally, the p-value (> 0.05) was non-significant, further confirming the model's acceptability. The Root Mean Square Error of Approximation (RMSEA) decreased from 0.061 to 0.035, with a p-value of 0.98, meeting the criteria for a well-fitting model.

Furthermore, other model fit indices also improved significantly post-modification: The Goodness of Fit Index (GFI) increased from 0.510 to 0.964, the Comparative Fit Index (CFI) moved from 0.380 to 0.978, the Tucker-Lewis Index (TLI) went up from 0.361 to 0.976, and the Incremental Fit Index (IFI) inched from 0.389 to 0.978. Conversely, the Expected Value of Change in Chi-Square (EVCI) decreased significantly from 24.834 to 1.262.

The final version of the TPI has 20 items, with a Cronbach's alpha of 0.802 and a 95% confidence interval, indicating high internal consistency. Table 2 delineates TPI's interactive and reflexive dimensions, showcasing 12 items for the interactive dimension and eight items for the reflexive dimension.

Table 2

Dimensions of Teacher Positioning with the Corresponding Number of Items

Dimensions	Number of Items	Indicators
Interactive	12	• Students' engagement and participation • Perceptions of what students can and cannot do
Reflexive	8	• Confidence in the ability to teach mathematics • Confidence in mathematics content
Total	20	

These items indicated how teachers positioned students based on their engagement and participation in the classroom and their perception of what students can and cannot do. On the other hand, the reflexive dimension of the TPI has eight items that indicate how teachers positioned themselves in terms of their ability to teach and their confidence in their knowledge of mathematics.

Research Instrument 2: Student Mathematics Identity Scale (SMIS)

The Student Mathematics Identity Scale (SMIS) is a tool designed to measure students' perceptions of their mathematics identity. Adapted from Laskasky (2018), this scale employs a 4-point Likert scale ranging from "not at all true to me" to "exactly true to me." Unlike previous qualitative studies, which mainly utilized narrative methods, the SMIS offers a quantitative approach to understanding mathematics identity.

Initially consisting of 40 items, the SMIS was piloted with 340 students, with 303 students included in the final analysis after data screening. The scale has two components, each represented by 20 indicators: core identity and normative identity. Bivariate correlation analysis ensured the importance of all items for factor analysis.

Following data screening, factor analysis was conducted, resulting in a composite measure with high reliability (Cronbach's alpha = 0.96). However, three items with low factor loadings were removed, leaving 36 items for confirmatory analysis. Initial results revealed the need for model modification, leading to the refinement of fit indices.

The final version of the SMIS provided valuable insights into how students perceived their mathematics identity. These can explain factors influencing students' self-perception in mathematics, ultimately informing strategies to enhance mathematics identity and academic achievement. Table 3 shows the final fit indices of students' mathematics identity.

Table 3

Fit Indices of the Final CFA Model for Student Mathematics Identity

Fit Indices	CMIN $\frac{x^2}{df}$	RMSEA	SRMR	GFI	CFI	TLI	IFI	EVCI
Value	412.038/404 [1.0198] p = .380	0.008 p = 1.0	0.068	0.985	1.000	1.000	1.000	1.768

The Fit Indices in Table 3 for the final Confirmatory Factor Analysis (CFA) model of the Student Mathematics Identity indicate a largely favorable fit. The χ^2/df ratio was 1.0198, slightly above 1, indicating an acceptable fit. The Root Mean Square Error of Approximation (RMSEA) was 0.008, showing a very low value and a strong fit. The Standardized Root Mean Square Residual (SRMR) was 0.068, below the common threshold of 0.08, indicating a favorable fit to the data.

Additionally, the Goodness of Fit Index (GFI) was 0.985, indicating that 98.5% of the observed covariance between variables was explained by the model, suggesting a strong fit. The Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), and the Incremental Fit Index (IFI) all had a value of 1.000, indicating an excellent fit. The Expected Cross-Validation Index (EVCI) was 1.768, suggesting the model is likely to maintain a good fit in new datasets.

The final version of the Student Mathematics Identity (SMI) Scale comprises 30 items with a Cronbach's alpha of 0.92. These items were divided into core identity and normative identity, with subdivisions based on different facets of mathematics identity. For example, items under natural face identity included beliefs about being a math person and confidence in math abilities. Items under imagination face identity focused on future aspirations in mathematics, while engagement face identity items related to active involvement in math tasks. Finally, alignment face identity items addressed awareness of math's importance in life and readiness for math activities. Table 4 shows the dimensions of the student mathematics identity instrument and the corresponding number of items.

Table 4

Dimensions of the Student Mathematics Identity with the Corresponding Number of Items

Dimensions	Subdimensions	Number of Items	Indicators
	Nature	8	• The belief of being a mathematics person • Confidence in doing mathematics • A belief that others see him/her as a mathematics person
	Imagination	7	• Looking at oneself to be doing mathematics in the future • Imagining oneself working with mathematicians • Planning to take a mathematics-related course in college
Normative (Identity as a Relationship with a Specific Practice)	Engagement	7	• Engagement in doing mathematics • Active participation in the mathematics classroom • Perform and complete assigned tasks
	Alignment	8	• Awareness of the importance of mathematics • Making oneself ready for mathematics activities • Awareness of the use of mathematics in life and schools

Research Instrument 3: Student's Perception of Mathematics Survey

The Student's Perception of Mathematics Survey was used to measure students' perceptions of mathematics based on their experience in the classroom during their previous years of study. Perception of mathematics due experience (PE) pertained to students' perception of mathematics due to their experience with mathematics teachers and classes. The items were based on different dimensions such as teacher personality, teaching strategies, methods/approaches, mathematics as a subject, and mathematics classes in general. Most items were based on the work of Green (2012). This instrument adopted a four-point Likert scale ranging from strongly disagree (1) to strongly agree (4). Higher scores represent a positive perception of mathematics due to experience.

The initial version of the instrument, composed of 40 items, was pilot-tested. This instrument was administered together with the other instruments of the study to 340 grade 11 SHS students. The completed questionnaires were sorted and screened, and respondents included in the factor analysis were identified.

The Shapiro-Wilk Test for Multivariate Normality showed a significant result that suggested a deviation from normality, so ULS was a more appropriate method for estimating the Factor Analysis (Osborne, 2014). The Kaiser-Meyer-Olkin (KMO) measure and the Bartlett's test of sphericity were used to determine if the data were suitable for factor analysis. The KMO coefficient and the Bartlett's test value for the 40 items passed the reliability test at 0.868 and p <.001, respectively. The overall KMO coefficient was found to be 0.817. However, the KMO coefficient of individual items ranged from 0.468 to 0.878, indicating that two items had to be deleted. Bartlett's test, meanwhile, indicated that the dataset was suitable for Factor Analysis. Principal axis factoring was used for factor extraction, and the predetermined number of factors of the PE construct was confirmed using a scree plot.

The Cronbach's alpha of the composite measure with 40 items was 0.89, indicating the high reliability of the measure. Based on factor loadings, out of the 38 items subjected to factor analysis, two items with a factor loading of less than 0.40 were deleted. The remaining 36 items were subjected to confirmatory analysis. The initial results of the confirmatory analysis showed that the modification indices were high, and the model fit indices were far from acceptable. The modification indices, specifically the cross-loading factor indices, were high, which suggested that more items had to be deleted. This resulted in the deletion of six more items. The resulting fit indices improved after the modification of the process model, as shown in Table 5.

Table 5

Fit Indices of the Final CFA Model for Students' Perception of Mathematics

Fit Indices	**CMIN** $\frac{x^2}{df}$	**RMSEA**	**SRMR**	**GFI**	**CFI**	**TLI**	**IFI**	**EVCI**
Value	315.485/402 [0.785] p = .05	0.000 p = 1.00	0.067	1.00	1.00	1.000	1.000	1.457

Table 5 presents the Fit Indices for the final Confirmatory Factor Analysis (CFA) model investigating students' perceptions of mathematics, revealing a model that fits well. The ▯^2/df ratio of 0.785 (315.485/402) indicated an acceptable fit, although it was slightly below 1. Notably, RMSEA is impressively low at 0.000, with a p-value of 1.00, demonstrating an exceptional fit. The SRMR value of 0.067 falls below the 0.08

threshold, indicating strong alignment with the observed data. Further enhancing the model's credibility, the GFI, the CFI, the TLI, and the IFI all held a value of 1.000, showing an ideal fit. Finally, the EVCI of 1.457 suggests a strong likelihood of the model maintaining its fit in new datasets.

The final number of items in the instrument measuring perception of mathematics due to the mathematics experience construct was reduced to 30, with a Cronbach's alpha of 0.89, with a 95% CI [0.87, 0.91]. Table 6 shows the dimensions and total number of items included in the final version of the instrument.

Table 6

Dimensions of the PE with the Corresponding Number of Items

Dimensions	Number of Items	Indicators
Mathematics teachers	12	• Pleasant personality • Engagement and enthusiasm • Care and support for students' learning • Promotion of the good image of Mathematics
Mathematics classes	18	• Interesting activities • Pleasant environment • Promotion of higher-order thinking • Promotion of the importance of mathematics

The results of the factor analysis showed that students' perception of mathematics (PE), based on the survey questionnaires, had two underlying dimensions that confirmed the initial number of factors identified when the questionnaire was developed. These dimensions were about students' perception of mathematics due to their experience with mathematics teachers and mathematics classes. The final version of the instrument was composed of 30 items. Of the total number of items, 12 pertained to students' perception of mathematics due to their experience with their mathematics teachers, and 18 pertained to students' perception of mathematics due to their experience with their mathematics classes.

Data Gathering Procedure

After the pilot testing and refinement of the research instruments, the researcher asked for approval from school divisions and individual schools. The study explained its objectives, addressed concerns, and established a convenient schedule for administering the surveys. To optimize data quality, teachers completed the Teacher Positioning

Inventory Survey (TPIS) individually in quiet spaces. Students, meanwhile, simultaneously answered the Student Mathematics Inventory Scale and Student Perception of Mathematics Survey in a classroom setting with clear instructions provided beforehand. Finally, after collecting all completed surveys, the researcher meticulously encoded the data into a digital format for analysis. Scoring followed established guidelines specific to each instrument.

Data Analysis

The study utilized Structural Equation Modeling (SEM) to explore the mediation effect of students' perception of mathematics on teacher positioning and student mathematics identity. This involved a measurement-of-mediation design (Bullock & Shang, 2011), where students' perceptions of mathematics acted as a mediator between teacher positioning and student mathematics identity. To examine the indirect effects, the study employed the product coefficient approach and conducted Sobel and Aroian tests.

Mediation analysis was chosen to elucidate the role of students' perceptions of mathematics in the relationship between teacher positioning and student mathematics identity. This statistical technique allows the investigation of whether the impact of teacher positioning on students' mathematics identity is partly or fully explained by their perception of mathematics. By employing mediation analysis, the study aimed to uncover the mechanisms through which teacher positioning influences students' mathematics identities, providing insights into the intricate relationships between variables.

Various subtypes of construct validity were employed to ensure that the measurement models accurately captured the intended constructs. Convergent and discriminant validity were assessed following the guidelines of Campbell and Fiske (1959) and Henseler et al. (2015).

Convergent validity was evaluated using the Fornell-Larcker criterion (1981), AVE, and CR. An acceptable AVE is 0.50 or higher, while CR should be 0.7 or above but below 0.95. Additionally, strong factor loadings without cross-loading indicate good convergent validity, with loadings ≥ .60 considered strong.

Discriminant validity was examined by comparing AVE values with the correlation coefficients between constructs. Discriminant validity is confirmed if the square root of the AVE for each construct exceeds its inter-dimensional correlation.

The scale's internal reliability was assessed using Cronbach's α and composite reliability values. The study found Cronbach's α values of 0.802, 0.969, and 0.972 for teacher positioning, students' perception of mathematics, and student mathematics identity, respectively. These indicated sufficient internal reliability. Composite reliability values were also above the 0.70 threshold for each construct, confirming composite reliability.

Results

This section presents the results of the mediation analysis examining how students' perception of mathematics mediates the relationship between teacher positioning and student mathematics identity. Using Structural Equation Modeling (SEM), the study employed various statistical tests, such as the product coefficient approach and Sobel and Aroian tests, to explore indirect effects. The section also outlines the approaches taken to assess construct validity, underscoring the importance of understanding the complex interplay between variables and ensuring the reliability and validity of the measurement models.

Teacher Positioning and Student Mathematics Identity

Table 7 displays the means, standard deviations, and outcomes of One-Way Analyses of Variance (ANOVA) conducted on Student Mathematics Identity (SMI) categorized by different levels of Teacher Positioning (TP).

Table 7

One-Way Analyses of Variance of SMI and TP

Measure	High TP		Low TP		F(1.506)	η2
	Mean	SD	Mean	SD		
SMI	3.534	0.304	2.479	0.535	745.835***	0.596

*** *p* < 0.001

The table, illustrating the means and standard deviations for students in the "High TP" and "Low TP" groups, shows a significant effect of teacher positioning on students' mathematics identity at $p < 0.001$ for both groups [$F(1, 506) = 745.835$, $p < 0.001$]. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for Low TP ($M = 2.479$, $SD = 0.535$) was significantly different from the mean score for High TP ($M = 3.534$, $SD = 0.304$). Moreover, using Tukey's test, the mean difference between the low and high TP [mean difference = 1.055, $t = 27.310$, $p < 0.001$] was significant. The effect size measure, η^2, demonstrated a substantial impact of 0.596, underlining the strong influence of TP on SMI. These findings highlight the statistically significant variation in SMI scores between students exposed to high and low TP levels, emphasizing the notable role that TP plays in shaping students' perceptions of their mathematical identity.

Teacher Positioning and Students' Perception of Mathematics Due to Experience

One-way between-subjects ANOVA was conducted to compare the effects of TP (Low TP and High TP) on PE. Table 8 shows the means, standard deviations, and outcomes of a one-way ANOVA examining the impact of Teacher Positioning (TP) on students' Perception of Mathematics Due to Experience (PE). The TP is categorized into High TP and Low TP groups.

Table 8

Means, Standard Deviations, and One-Way Analyses of Variance of Student's Perception of Mathematics Due to Experience (PE) by Teacher Positioning (TP)

Measure	High TP		Low TP		F(1.506)	η2
	Mean	SD	Mean	SD		
PE	3.189	0.322	2.601	0.678	155.029***	0.235

*** $p < 0.001$

Teacher positioning had a significant effect on students' perception of mathematics based on experience ($p < 0.001$ for both groups [$F(1, 506) = 155.029$, $p < 0.001$]. This indicates substantial variations in PE scores based on the different levels of TP. Furthermore, post-hoc comparisons using the Tukey HSD test indicated that the mean score for Low TP ($M = 2.601$, $SD = 0.678$) was significantly different from the mean score for High TP ($M = 3.189$, $SD = 0.322$). Moreover, using the Tukey test, the mean difference between Low TP and High TP [mean difference = 0.589, $t = 12.451$, $p < 0.001$] was significant. The effect size, η^2, was 0.235, suggesting a moderate influence of TP on PE. These results underscore the significant impact of TP on students' perception of mathematics based on experience and highlight the role of TP in shaping how students perceive their mathematical learning experiences.

Students' Perception of Mathematics and Student Mathematics Identity

The analysis demonstrated a significant positive correlation between students' perceptions of mathematics due to experience and their mathematics identity ($r = 0.52$, $p < 0.01$). This suggests that students who perceive their experience in mathematics more positively tend to have a stronger sense of mathematical identity. The statistical significance of the correlation reinforces the notion that these two aspects are interconnected and mutually reinforcing, underlining the potential impact of positive experiences on students' sense of identity in mathematics.

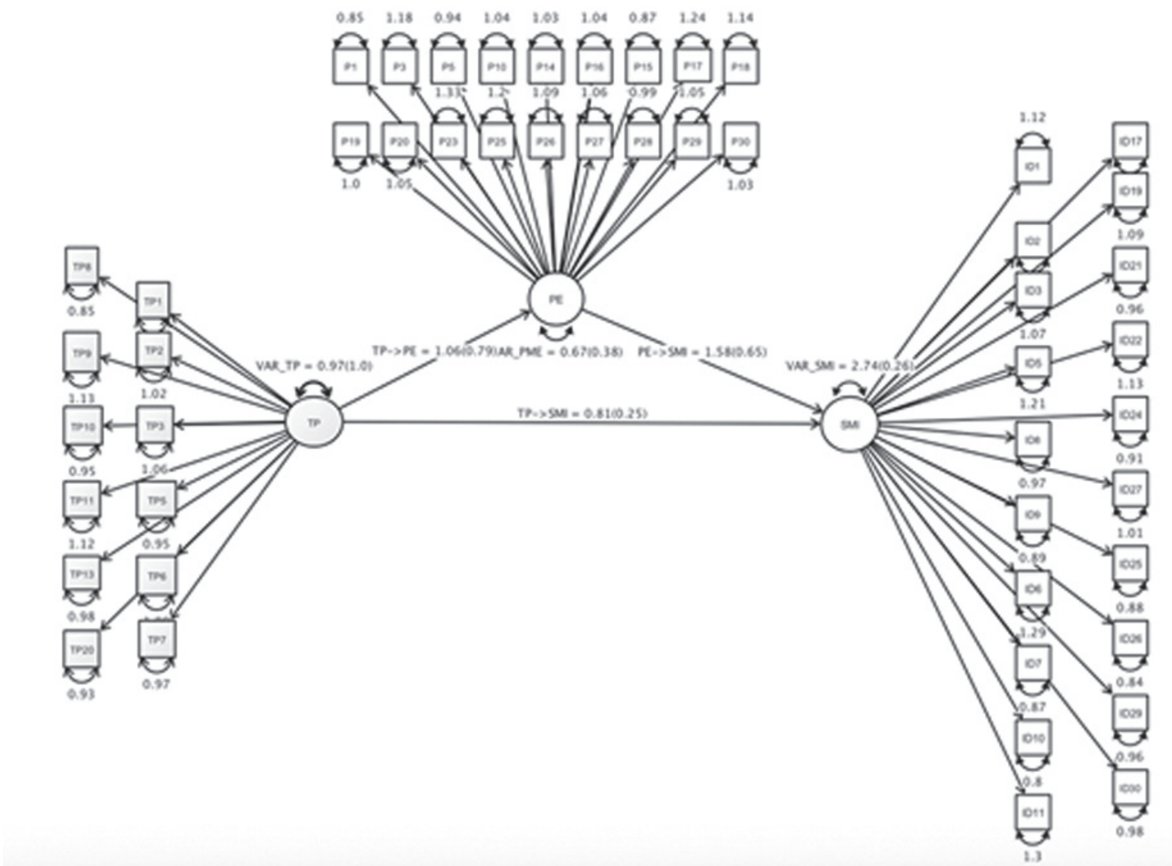
Conversely, the ANOVA results indicated notable differences in mathematics identity ($F(1,506) = 745.835$, $p < .05$) and perception of mathematics due to experience ($F(1, 506) = 155.029$) based on teacher positioning. Moreover, teacher positioning accounted for 59.6% of the variability in SMI scores. However, teacher positioning explained only 23.5% of the variability in the perception of mathematics due to experience (PE). These findings highlight the substantial influence of teacher positioning on students' mathematical identity and provide insights into the varying degrees of impact of experience on students' perception of mathematics.

Teacher Positioning and its Influence on Student Mathematics Identity

The mediation model shown in Figure 1 illustrates the relationship between teacher positioning, students' perceptions of mathematics, and students' mathematics identity. The model shows that students' perception of mathematics significantly mediates the relationship between teacher positioning and student mathematics identity, with a significant direct effect of teacher positioning and a significant total effect. The unstandardized and standardized (in parentheses) path coefficients are included in the figure to provide a more detailed understanding of the magnitude and direction of these effects.

Figure 1

Model Showing Teacher Positioning and Student Mathematics Identity Mediated by Students' Perception of Mathematics



Note: TP refers to teacher positioning; PE refers to students' perception of mathematics; SMI refers to student mathematics identity

The structural equation model presented in this study demonstrated the relationship between teacher positioning and student mathematics identity, mediated by students' perceptions of mathematics. The model fit indices were all highly acceptable, with CMIN= 0.988, $p > 0.05$; TLI = 1.0, CFI= 1.0, SRMR = 0.024, and RMSEA = 0.00, indicating a good model fit (Hu & Bentler, 1999).

Table 9 shows the indirect and total effects of PE as a mediator of the relationship between TP and SMI.

Table 9

Indirect and Total Effects with PE as a Mediator of the Relationship Between TP and SMI

Path	Estimate	Standard Error	z-value	Indirect Effect	95 % Confidence Interval	Total Effect	VAF %
TP→SMI	0.8086	0.1428	5.66*				
PE→SMI	1.5796	0.1035					
			15.26*	1.68*	[0.974, 2.383]	2.49*	67.47%
TP→PE	1.0626	0.0429					
			24.77*				

**Significant at p =.01*

The TP → SMI path showed an estimate of 0.8086, robustly signifying a positive and influential connection between teacher positioning (TP) and student mathematics identity (SMI). The associated z-value of 5.66 validates the statistical significance of this link. This effect is further clarified by the indirect effect calculated at 1.68, which underscores TP's role in shaping SMI through the mediating influence of students' perception of mathematics (PE). The 95% confidence interval [0.974, 2.383] adds depth by presenting a plausible range within which this mediated effect lies. The total effect, quantified at 2.49, seamlessly integrated both the direct and indirect influences of TP on SMI. Remarkably, this pathway illuminated 67.47% of the variance in SMI scores, representing a substantial and far-reaching impact.

The PE→SMI path demonstrates an estimate of 1.5796, as evidenced by the z-value of 15.26. This accentuates the direct link between students' perceptions of mathematics due to experience (PE) and their mathematical identity (SMI). Furthermore, the TP →PE path yields an estimate of 1.0626, which was strikingly validated by an impressive z-value of 24.77. This outcome highlights the connection between teacher positioning (TP) and students' perceptions of mathematics due to experience (PE).

Moreover, the study's outcomes showed a substantial variance accounted for (VAF) of 67.47%, indicative of a scenario characterized by partial mediation. Essentially, this underscored that 67.47% of the influence of teacher positioning on student mathematics identity was channeled through the mediating avenue of students' perceptions of mathematics. This suggests that additional factors beyond perception also contributed to the complex influence of teacher positioning on student mathematical identity although students' perceptual lens of mathematics played a pivotal role in mediating this relationship.

Students' Perception of Mathematics as a Mediator Between Teacher Positioning and Student Mathematics Identity

The results of the mediation analysis revealed significant path values at p = .01, indicating that students' perceptions of mathematics significantly mediated the relationship between teacher positioning and student mathematics identity. Two commonly used tests, the Sobel test and the Aroian test, were employed to further test the significance of the direct and indirect effects. These tests are commonly used in structural equation modeling to assess the significance of mediation effects and are known to have good statistical power in many situations. Both tests yielded significant results at $p < 0.01$, with a Sobel test statistic of 12.993 (SE = 0.1292) and an Aroian test statistic of 12.986 (SE = 0.1293). Furthermore, the mediation analysis in this context, with the perception of mathematics serving as the mediator, indicated partial mediation. This insight sheds light on the multifaceted interplay of factors and underscores that other influences beyond perception contribute significantly though students' perception of mathematics plays a pivotal role in mediating the teacher positioning–student mathematics identity relationship.

DISCUSSION

The present study investigated the impact of teacher positioning on two key aspects of students' mathematical development: their mathematics identity (SMI) and their perceptions of mathematics due to experience (PE). By examining the interplay of these elements, the research uncovered the intricate dynamics within the classroom environment and their implications for students' attitudes and beliefs towards mathematics.

Direct Effect of Teacher Positioning on Student Mathematics Identity

The examination of the direct impact of teacher positioning on student mathematics identity (SMI) yielded intriguing findings. The results showed a significant influence of teacher positioning on SMI, affirming its role in shaping students' perceptions of themselves in math, as noted in earlier research (Grootenboer & Hemmings, 2007). Statistical analysis, using analysis of variance, emphasized the strong relationship between teacher positioning and SMI, with approximately 59.6% of SMI variability attributed to teacher positioning. This underscores the pivotal role teachers play in molding students' mathematical identities, echoing previous studies that show the importance of teacher practices (Hembree, 1990; Hima et al., 2019). Post-hoc comparisons with the Tukey HSD test provided additional support for the influence of teacher positioning on students' mathematical identities. The distinct difference in SMI between low teacher positioning (Low TP) and high teacher positioning (High TP) groups underscored the connection between teacher behaviors and students' perceptions of themselves in math. Students in the High TP group exhibited more positive and robust mathematical identities, highlighting the positive impact of effective teacher positioning on students' attitudes and beliefs (Grootenboer & Hemmings, 2007). These findings demonstrate the importance of teachers' actions and approaches in fostering positive attitudes toward math among students. They show how teaching methods can significantly affect students' feelings and engagement with math, underscoring the crucial teacher-student relationship in enhancing learning experiences. Overall, these results align with previous research emphasizing the impact of teacher practices on students' attitudes and experiences in mathematics (Hima et al., 2019; Pianta et al., 2012; Wong et al., 2019).

The significant impact of teacher positioning on students' perception of mathematics due to experience underscores the critical role of teachers' instructional strategies and classroom environments in shaping students' attitudes and beliefs about math. Teachers who employ engaging and meaningful instructional approaches, cultivate a supportive learning environment, and promote a growth mindset can profoundly influence students' perceptions and experiences with math (Dweck, 1986; Hima et al., 2019; Pianta et al., 2012; Wong et al., 2019). This highlights the importance of how teachers teach and the classroom atmosphere they create. It is not solely about the subject itself; rather, it is about how teachers make students feel about math. By using methods that maintain student interest and motivation and by fostering a belief in students' ability to improve their math skills, teachers can enhance students' overall experiences with mathematics.

Mediating Role of Students' Perception of Mathematics

The examination of how teacher positioning influences students' perception of mathematics due to experience (PE) reveals the significant role educators play in shaping students' attitudes toward math. Statistical analysis highlights that approximately 23.5% of the variability in PE can be attributed to teacher positioning, emphasizing the influential impact of teacher practices on students' perceptions (Pianta et al., 2012; Wong et al., 2019). Further reinforcing this effect, post-hoc comparisons illustrate distinct differences between groups with low and high teacher positioning. Specifically, students in the high teacher positioning group demonstrate a more positive perception of mathematics due to experience, underscoring the efficacy of effective teacher strategies in enhancing students' engagement and viewpoint (Pianta et al., 2012; Wong et al., 2019). Moreover, the mediation model depicted in Figure 1 elucidates the intricate relationship between teacher positioning, students' perception of mathematics, and student mathematics identity. This model underscores the significant role of students' perception of mathematics as a mediator between teacher positioning and students' mathematics identity, which is in line with previous research findings (Appiah et al., 2023; Klein, 2000). The structural equation model utilized in this study aligns with empirical data, enhancing the credibility and reliability of the findings. The significant path coefficients identified within the model emphasize the impact of teacher positioning on students' perception of mathematics and, consequently, their overall mathematical identity, as observed in prior studies (Boaler, 2002; Hima et al., 2019; Pianta et al., 2012; Wong et al., 2019; Yamakawa, 2014). Additionally, the study reveals that approximately 67.47% of the influence exerted by teacher positioning on students' mathematical identity is channeled through their perceptions of mathematics, further supporting the notion of a complex interplay between teacher behavior, student perceptions, and the development of mathematical identity (Appiah et al., 2023; Boaler, 2002; Cai et al., 2018; Hima et al., 2019; Pianta et al., 2012; Wong et al., 2019; Yamakawa, 2014). Furthermore, educators' instructional strategies that bridge mathematics with real-world contexts contribute significantly to students' perceptions of the practical and applicable facets of mathematics, aligning with previous research recommendations (Harackiewicz et al., 2016). By fostering connections between mathematical concepts and tangible real-world scenarios, teachers cultivate an environment where students view mathematics as relevant, promoting resilience and achievement in the discipline. Overall, the study's data show students' construction of their self-perception as mathematics learners is fundamentally influenced by their experiences in mathematics classrooms and their interactions with teachers, peers, and parents. These interactions form a strong foundation of students' mathematics identity and significantly influence their academic achievement and aspirations in the subject.

CONCLUSION

The findings highlight the significance of teacher positioning and students' perceptions of mathematics in shaping their identity. They indicate that teacher positioning has both direct and indirect effects on students' mathematics identity, with students' perceptions of mathematics acting as a significant mediator in this relationship. Thus, how teachers design their instructional approach affects students' perspectives on mathematics. These perspectives are intricately intertwined with the development of students' mathematical identities, which improves their involvement and progress. The interdependent relationship among these variables underscores the complex nature of the learning process and exerts an influence on students' dispositions and achievements in mathematics.

This study recommends empowering teachers to position themselves strategically and use effective teaching practices to foster favorable student perceptions and nurture a robust mathematical identity. Strategies include creating engaging learning environments, valuing student contributions, and integrating problem-based learning with real-world mathematics applications. Professional development programs are also crucial because they equip teachers with the skills needed to develop an environment conducive to positive student mathematics perception and robust mathematics identity. If successful, these efforts can result in meaningful advances in mathematical learning. Future research should explore additional factors such as family and cultural background, gender, socioeconomic status, and the role of technology to gain a more comprehensive understanding of the dynamics that influence students' mathematics identity.

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