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Belief System Theory in Learning Mathematics: The Case of Basic Education in the Philippines

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Abstract

Understanding how students learn mathematics concepts is an essential factor in shaping how the students view the subject and building a solid foundation in their ability to apply these ideas. The study aimed to address the existing gap by investigating Rokeach's Belief System Theory through the lens of Mathematics learning. The study uses Partial Least Squares Structural Equation Modeling (PLS-SEM) to explore the connections between beliefs, values, and attitudes in mathematics learning from the 518 randomly selected elementary students. The findings revealed a direct connection between these three main constructs, highlighting that a positive belief about mathematics increased students' perceived worth of the subject, which developed positive attitudes, resulting in a self-reinforcing cycle that supported and improved mathematical learning and engagement. With this, different stakeholders may foster a more supportive and engaging learning environment for the learners. Teaching students in context, connecting concepts to real-life scenarios, and emphasising relevance and value will foster deeper understanding, motivation, and achievement in mathematics.

Keywords: Beliefs in learning Mathematics, values in learning Mathematics, attitude in learning Mathematics

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INTRODUCTION

Mathematics education in primary schools should be designed to correspond with the cognitive development stages of children, hence facilitating the integration of mathematical concepts (Yuza, 2018). Moreover, elementary school mathematics education equips students with critical, rational, logical, and creative thinking abilities, enabling them to effectively confront the obstacles of the fourth industrial age (Lestari, 2020). The study conducted by Turgut and Turgut (2020) highlights the importance of mathematics instruction, especially in elementary schools, as this is the first time kids are introduced to the subject. Additionally, they asserted that pupils' first experiences of achievement or disappointment in mathematics occur throughout elementary school.

Several international studies examined mathematical beliefs, values, and attitudes. Ayebo and Mrutu (2019) researched students' beliefs about mathematics in the United States. Mutodi and Ngirande (2014) discovered that students' perceptions about mathematics, such as self-confidence, interests, teacher support, and myths, positively impact their performance in the subject. A study in Pakistan revealed that pupils with positive beliefs in mathematics exhibit higher levels of satisfaction and enthusiasm towards learning (Bibi, Zaman, & Idris, 2020). In Israel, however, elementary students regard mathematics as difficult and complex (Markovits & Forgasz, 2017). In Hong Kong, the early acquisition of mathematical skills is shaped by a combination of Chinese cultural values, which prioritise hard work, self-control, and academic success, and the Western belief in placing the child at the centre of the learning process (Ng & Sun, 2015). Meanwhile, a study conducted in Tanzania demonstrated that students' initial positive attitude toward mathematics decreases as they progress through their education, with their performance being substantially predicted by their enjoyment and attitude (Manzana, Montero, & Casmir, 2018).

Studies in various ASEAN countries demonstrate how students’ positive beliefs, values, and attitudes towards mathematics are significantly linked to improved achievements. For example, Bakar, Ayub, Gopal, and Salim (2019) found that Malaysian students hold positive beliefs about mathematical problem-solving, and there is a significant positive relationship between the overall beliefs and mathematics achievement. Kanauan, Inprasitha, Changsri, and Sudjammong (2019) also mentioned that 100% of student interns in the mathematics education program perceived the four values: building collaboration, open-minded attitudes, public concern, and emphasis on the product-process approach. Students' attitudes from Jakarta positively and significantly impact mathematics learning outcomes (Ventini, Hartati, and Sukardjo, 2018). Likewise, Botty, Taha, Shahrill, and Mahadi (2015) have shown that students' mathematics achievement is significantly and positively correlated with their positive attitudes. These studies highlight that fostering positivity among students is essential in enhancing their learning outcomes in Mathematics.

Furthermore, several studies have been conducted in the Philippines using correlational research. Sediarin, Parangat, and Ablian (2023) have stated that students' academic achievement is influenced by their beliefs and values regarding mathematics education. Also, Limbaco (2015) revealed that values taught and learned positively impact students' attitudes and performance in mathematics, with moral strength, sharing, charity, valuing life, love of God, truth, and honesty being the most significant factors. According to Etang and Regidor (2022), students' mathematical attitudes significantly predict their mathematical abilities in terms of confidence, importance, and engagement. They discovered that the more advanced a student's mathematical abilities are, the more positive their attitudes and beliefs about mathematics are.

Additionally, Dela Cruz (2018) stated that students maintain optimistic attitudes and beliefs regarding mathematics. Consequently, the main goal of this study was to address the existing gap by evaluating Rokeach's (1968) belief system theory, which proposed a connection between beliefs, values, and attitudes. Thus, the following research questions were addressed in this study. Do students’ beliefs in learning mathematics significantly and directly affect their values in learning Mathematics? Do students’ values in learning mathematics significantly and directly affect their attitudes toward learning Mathematics? Lastly, do students’ attitudes toward learning mathematics significantly and directly affect their beliefs toward learning Mathematics? The study could provide a deeper understanding of how students differ in learning styles, particularly Mathematics. It will also offer insights into how teachers can help enhance students' learning experiences, guiding them to create a more practical approach that aligns with their cognitive and emotional development.

Framework of the Study

The study utilised Milton Rokeach's (1968) Belief System Theory as its theoretical foundation and basis. Attitudes originate from our internal convictions and values. Beliefs are presumptions and convictions that, based on previous experiences, we hold to be true. Valuable concepts are derived from entities, notions, and individuals. These variables substantially impact the capacity to acquire and organise skills and knowledge. In order to facilitate change within an organisation or learning environment, it is imperative to comprehend the fundamental distinctions between these concepts (Kumar, 2022). In 1969, Rokeach conducted a comparative analysis of values, beliefs, attitudes, and behaviours. He stated that values are the foundation for one's beliefs, attitudes, and behaviour. Thompson (1992) argues that belief systems are dynamic, impervious mental structures susceptible to change in response to experience. Though these arguments show the interconnectedness of the main constructs, the study will mathematically prove its relationship as the gap of this study. Figure 1 below is the paradigm of the study.

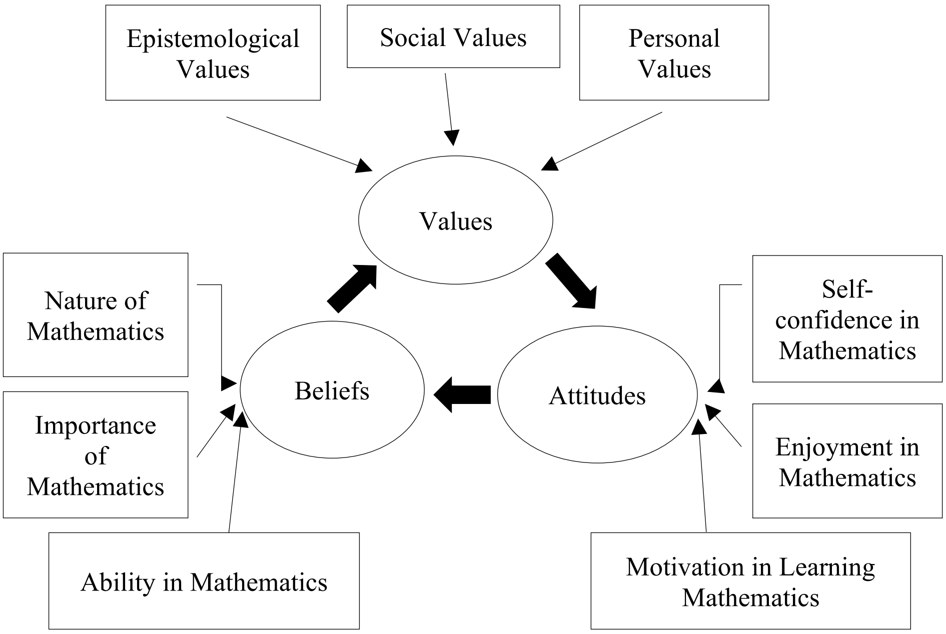

Figure 1. Paradigm of the Study

Hypothesis Development

In mathematics, beliefs align about one's skills or the usefulness of mathematics in daily life, while values are about getting things right, solving problems, and being creative (Hestner & Sumpter, 2018). Students who strongly embraced perseverance were discovered to have interconnected beliefs about mathematics, compared with their peers who did not value perseverance as highly (Seah et al., 2022). Gaspard et al. (2015) added that with the help of relevant interventions in the classroom, it is possible to affect adolescents' value beliefs over time. Thus, the hypothesis was developed:

Ha1: *Beliefs in learning mathematics affect student's values in mathematics.*

The studies look at the impacts of values on the behaviour and performance of students in mathematics. Limbaco (2015) suggests that values instructed and learned in school can positively influence the attitude and performance of students in the subject. Moreover, Kudinov et al. (2021) contend that specific prevailing qualities and the degree of obligation can decide understudies' mentalities toward functions like lockdowns, which may influence their performance in mathematics. Additionally, Laranang and Bondoc (2020) highlight the importance of co-relation on attitudes and self-confidence in mathematics and the impact of factors such as parental education and mother occupation on students' values regarding mathematics. Thus, the hypothesis is tested:

Ha2: *Values in learning mathematics affect students' attitudes in learning Mathematics.*

Hannula et al. (2016) found a robust positive affiliation between students' attitudes toward mathematics, their thoughts about the topic's nature, and their claims of mathematical capabilities. These attitudes included fulfilment, interest, and comfort of the subject. In a comparative vein, a meta-analysis conducted by Mata et al. (20120) found that students' attitudes toward mathematics expected their beliefs and self-concept in mathematics. Other than that, a longitudinal study by Guo et al. (2017) showed a strong correlation between changes in students' mathematical emotions and self-efficacy and how they felt around mathematics over time.

Ha3: *Attitudes in learning Mathematics affects student's beliefs in learning Mathematics*

METHODS

Research Design

The study employed a quantitative methodology utilising the statistical method of partial least squares structural equation modelling (PLS-SEM). This approach was selected to assess the proposed hypotheses, analyse the gathered data, and establish the correlations between individuals' values, beliefs, and attitudes towards learning. According to Creswell (2014), quantitative research was a study that tested a theory composed of state or humanistic problems and utilised quantifiable measures, which were analysed through statistical procedures. This method addressed the generalizability of the theoretical predictions underlying such theories. Structural equation modelling (SEM) is a statistical technique used to investigate and predict the causal relationships between and effects among variables suggested in theoretical models. In this regard, the partial least squares (PLS) method was used within the framework of structural equation modelling (SEM) to achieve these specific goals (Gonzales, Tarango, & Mastromatteo, 2018).

Participants

The validated response comprised 518 students from Grades 5 and 6 enrolled in public elementary schools in Zambales, Philippines. These students were randomly selected participants from different elementary schools. A post hoc analysis was conducted to determine the sufficiency of the responses. Based on the calculations, the inverse square root and gamma-exponential methods, as suggested by Kock and Hadaya (2018), require a sample range of 71 – 101 participants. Thus, there was ample evidence that the number of respondents was sufficient, as there were 518 validated responses, as illustrated in Figure 2.

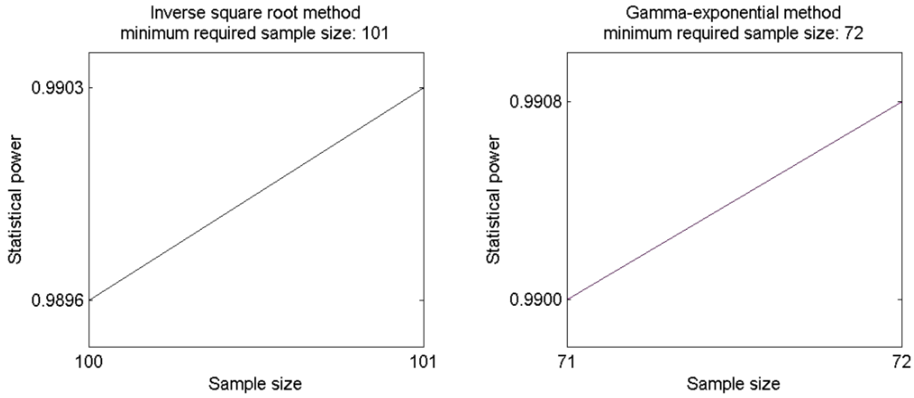

Figure 2. Results of the inverse square root and gamma-exponential methods

Instruments

The primary tool for gathering the data and information of the participants was a survey questionnaire. The researcher adapted the survey instrument from the study of Sediarin, Parangat, and Ablian (2023) for the student's beliefs and values in learning mathematics and from the study of Majeed, Darmawan, and Lynche (2013) for their attitude toward learning Mathematics.

Each construct is categorised into sub-variables containing five items each. The beliefs in learning Mathematics were measured in terms of nature, importance, and ability in Mathematics. Epistemological, social, and personal values were considered as subgroups for the values in learning Mathematics. Lastly, the attitude in learning Mathematics was divided into self-confidence, enjoyment, and motivation. The questionnaire falls under higher-order constructs, as Becker et al. (2012) explained. The adapted questionnaire was translated into Filipino language for elementary students understand the statements easily. A rating scale was used to describe the beliefs, values, and attitudes of the participants in mathematics: 4 (very high), 3 (high), 2 (moderate, and 1 (very low). Its content was validated by seven (7) validators: mathematics elementary teachers from DepEd and the research panellists. Using the content validation method (Polit & Beck, 2006; Davis, 1992) and the guidelines described by Cicchetti and Sparrow (1981) and Fliess (1981) in evaluation criteria for kappa, it was found that the statements on beliefs (0.987), values (0.93), and attitudes (0.867) in learning mathematics possessed excellent content validity results.

Data Collection

Upon acceptance of the survey instrument, we sought the school division superintendent's approval. It was followed by distributing a permission letter to the school principal and an assent form to the participants' parents. Once approved, the instruments were distributed to the students, explaining the objectives and purpose of the study and stating that the data would be treated with the utmost confidentiality.

Data Analysis

The study employed a quantitative research design that utilised PLS-SEM to examine the significant and direct effects of the three variables—beliefs, values, and attitudes—in learning mathematics. The partial least squares structural equation modelling was estimated using the parameters of the mediation model through the WarpPLS 6.0 software. PLS-SEM was a variance-based estimation method that calculated the reliability and validity of the constructs. With these measures, the relationships were analysed (Reinartz, Haenlein, & Henseler, 2009). The analysis in PLS-SEM consisted of two stages: the measurement model and the path model. In the first phase, the measurement model was assessed. During this phase, the reliability and validity of the variables were measured. The structural model was estimated in the second stage, and the hypothesised relationships among variables were analysed.

RESULTS & DISCUSSION

Results

Model Fit and Quality Indices

One of the goals of the investigation is to determine whether the model fits the data better than the alternative (Kock, 2017). Therefore, it is essential to use many indices to assess the model's quality, as presented in Table 1.

Table 1. Model Fit and Quality Indices of SEM

Index	Coefficient
Average path coefficient (APC)	0.744, P<0.001
Average R-squared (ARS)	0.557, P<0.001
Average adjusted R-squared (AARS)	0.554, P<0.001
Average full collinearity VIF (AFVIF)	3.010, acceptable if <= 5, ideally <= 3.3
Tenenhaus GoF (GoF)	0.532, small >= 0.1, medium >= 0.25, large >= 0.36

According to Kock (2017), for the model to be acceptable, the p-values for APC, ARS, and AARS must be equal to or lower than 0.05. The AFVIF meets the acceptable threshold, and GoF indicates a good overall model fit. With this, the models meet the acceptable value and fall within acceptable ranges.

Reliability and Validity of Measurements

The validity and reliability of variables are the primitive factors that confirm the strength of this study (Straub D. et al., 2004). Two of the most commonly used reliability indicators, which are Cronbach's alpha and Composite reliability, are referred to (Kock N., 2017). Both are utilised in Table 2, as illustrated. The same conditional criteria of the respective composite reliability scores and Cronbach's alpha should be equal to or even more significant than 0.7 (Fornell & Larcker, 1981; Nunnally,1978; Nunnally & Bernstein, 1994). Each item's p-value should be equal to or less than 0.05. Loadings should equal or exceed 0 to attain an appropriate degree of convergent validity 5 (Kock, 2017; Hair, Black, Babin, & Anderson, 2009). Thus, items that do not attain the specified value are removed.

Table 3. Reliability and Convergent Validity of Items on Subcontructs

Construct/Item	Indicator Loadings	AVE	CR
Nature of Mathematics			
NM2	0.783	0.612	0.760
NM3	0.783		
Importance of Mathematics			
IM1	0.728	0.564	0.795
IM3	0.755		
IM5	0.770		
Student's Ability in Mathematics			
SA2	0.802	0.644	0.783
SA3	0.802		
Epistemological Values			
EV1	0.813	0.569	0.797
EV2	0.659		
EV3	0.783		
Social Values			
SV1	0.730	0.552	0.710
SV2	0.558		
SV5	0.715		
Personal Values			
PV1	0.750	0.569	0.798
PV2	0.809		
PV4	0.698		
Self-Confidence in Mathematics			
SM2	0.722	0.525	0.768
SM3	0.706		
SM4	0.745		
Enjoyment in Mathematics			
EM1	0.701	0.505	0.803
EM2	0.668		
EM3	0.739		
EM5	0.732		
Motivation for Learning Mathematics			
MM2	0.744	0.536	0.776
MM3	0.704		
MM4	0.748		

AVE *= Average Variance Extracted* ***CR*** *= Composite Reliability*

The items in Table 2 revealed satisfactory indicator loadings across all constructs, with values consistently more significant than 0.5, indicating that the items were well comprehended and corresponded with the constructs' aims. It means that the participants understand each construct's items or question statements in the same way that the designers intended (Kock, 2017). Each latent variable's AVE surpasses 0.5, the recommended threshold for acceptable Validity (Lacap, 2019; Fornell & Larcker, 1981).

As illustrated in Table 3 below, all indicator loadings, which quantify the relationship between each item and its corresponding construct, exceed 0.5, signifying robust connections.

Table 3. Indicator Loadings, AVE, and Reliability Measures for Main Constructs

Construct/Item	Indicator Loadings	AVE	CR
Beliefs in Learning Mathematics (BM)			
Nature of Mathematics	0.703		
Importance of Mathematics	0.762	0.521	0.765
Student's Ability in Mathematics	0.699		
Values in Learning Mathematics			
Epistemological Values	0.830		
Social Values	0.771	0.684	0.866
Personal Values	0.876		
Attitude towards Mathematics			
Self-Confidence in Mathematics	0.840		
Enjoyment in Mathematics	0.865	0.662	0.854
Motivation for Learning Mathematics	0.729		

The Average Variance Extracted (AVE) values, which represent the proportion of variance explained by the construct indicators compared to measurement error, were above the widely recognised threshold of 0.5 (Lacap, 2019; Fornell & Larcker, 1981), which indicated that there was good external validity of the constructs based on their indicators. These findings supported the claim that the constructs explored in the study were usable for reliable and valid measurements of the students' beliefs, values, and attitudes towards mathematics education.

Table 4 presents the results of the discriminant validity research for three constructs using the Heterotrait-Monotrait ratio of correlation (HTMT2) criteria. The HTMT ratio must be less than 0.90 (Henseler et al., 2015).

Table 4. Discriminant validity using HTMT2

	Beliefs in Learning Mathematics	Values in Learning Mathematics	Attitude towards Mathematics
Beliefs in Learning Mathematics	-	-	-
Values in Learning Mathematics	0.832, P<0.001	-	-
Attitude towards Mathematics	0.804, P<0.001	0.846, P<0.001	-

The results suggested that the constructs are related. The discriminant validity of the latent variables was subsequently assessed using the HTMT ratio of correlations criterion.

Model Results

The model used to confirm the significant and direct effects of the variables is illustrated in Figure 3. Beliefs regarding learning mathematics are strongly associated with values in mathematics learning ($\beta = 0.61$, $p<0.001$). In the same way, values in learning mathematics have a strong and meaningful relationship with attitudes in learning mathematics, based on a standardised coefficient of 0.72 ($p < 0.001$).

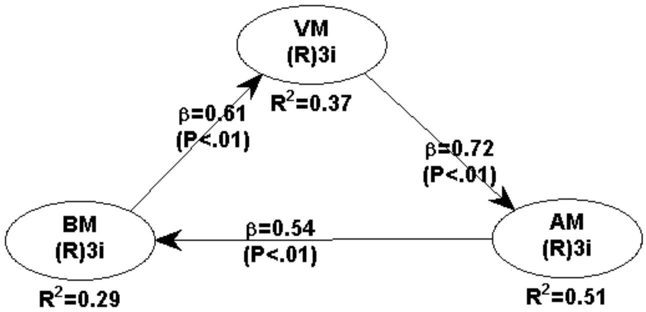

Figure 5. The Direct Effects Model with parameter estimates

Meanwhile, it shows that respondents' attitudes significantly affect their beliefs in learning mathematics; the results evidenced a standardised path coefficient of 0.54 ($p<0.001$).

The analysis conducted, as presented in Table 5, revealed that a strong relationship existed between the primary constructs of the study. It confirms the acceptance of the hypothesis.

Table 5. Direct Effects of the PLS Path Model

Direct Effects	β	SE	P-value	f^2	Decision
Ha1: $BM \rightarrow VM$	0.612	0.041	<0.001	0.374	Supported
Ha2: $VM \rightarrow AM$	0.715	0.040	<0.001	0.512	Supported
Ha3: $AM \rightarrow BM$	0.536	0.041	<0.001	0.287	Supported

f^2 is the Cohen's (1988) effect size: 0.02 = small, 0.15 = medium, 0.35 = large. SE = standard error, β = standardised path coefficient

Discussion

The findings revealed that beliefs, values, and attitudes in learning Mathematics directly and significantly affect each other, further confirming the theory of Rokeach (1968). The findings indicated that what a student believed about their ability in Mathematics significantly impacted how they felt about it. Sediarin, Parangat, and Ablian (2023) supported the idea that a student's achievement is influenced by several beliefs and values existing with respect to education in mathematics. The values taught and learned in mathematics education positively influence students' attitudes and performance (Limbaco, 2015). A student's mathematical beliefs and attitudes are fair indicators of mathematical skills, and the varied instructors' role is critical in predicting these abilities (Etang & Regidor, 2022). These characteristics influenced how people engaged in mathematical activities, shaped their perceptions of their mathematical ability and affected their assessments of the importance of mathematics in their lives. In this regard, it was consistent with the study by Guo et al. (2015) and Kalogeropoulos and Bishop (2019), which indicated that students' values in mathematics education could lead to positive outcomes, including academic achievement, active involvement in mathematical activities, and the development of good relationships between peers. Also, Smith and Jones (2018) and Lee and Kim (2021) supported the idea that students with more positive attitudes towards mathematics were more likely to hold the belief that mathematics is a valuable and important subject. In addition, Choi and Park (2022) state that positive attitudes play a role in forming students' beliefs over time.

Moreover, these studies highlighted the importance of respect, as well as the development of enthusiasm and positive attitudes towards mathematics. Values such as self-efficacy and perseverance were associated with practical learning in mathematics. Seah (2022) noted that these values were necessary for enhancing positive mathematical achievement. It was found that students generally held positive attitudes and beliefs about mathematics (Dela Cruz, 2018). Furthermore, Dela Cruz (2018) stressed that students' attitudes and beliefs were highly influential to their academic performance regarding their performance in various courses. In another study conducted by Ayuman-Valdez and Guiab (2015), it was found that pupils had a positive attitude towards mathematics because they found the subject to be interesting, which coincided with their experiences regarding the development of their intellect in the subject. Also, mathematics learning is designed for all students, and considering their beliefs, values, and attitudes will surely help improve their mathematical abilities (Unam et al., (2024). Motivation, as mentioned by Ningsih et al. (2024), influences student's mathematical ability in relation to their habits. These findings collectively underscore the significant role of attitudes, values, and motivation in shaping students' mathematical achievement, emphasising the importance of nurturing both the cognitive and affective dimensions of learning.

CONCLUSION

The study highlights that the students' beliefs, values, and attitudes are significant and directly affect one another in mathematics learning. Thus, Rokeach's belief system theory (1968), which implies a link between values, beliefs, and attitudes, was proven. It emphasises the importance of beliefs, values, and attitudes in learning mathematics. Positive beliefs about mathematics can increase students' values and perceived worth of the subject, which develops positive attitudes, resulting in a self-reinforcing cycle that supports and improves mathematical learning and engagement. With this, a strong and positive mindset can help enhance student's understanding and improve their Mathematical skills through effort and practice. Encouraging students to develop a good study habit will lead them to be participative and relate better. The present study only proves the relationship between beliefs, values, and attitudes in mathematics learning among elementary students in Zambales, Philippines. Thus, conducting this study in a larger setting and other participants to understand more about this context is possible. It is also possible to conduct this study using a multi-group analysis in high schools and colleges to better understand students' beliefs, values, and attitudes. Other variables, such as mathematical skills, may be incorporated into the constructs to determine whether the present variables affect their ability in mathematics.

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