Asia-Pacific Edu Res (2024) 33:253–262
https://doi.org/10.1007/s40299-023-00724-2

REGULAR ARTICLE

The Role of Students' Beliefs, Parents' Educational Level, and The Mediating Role of Attitude and Motivation in Students' Mathematics Achievement

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Accepted: 15 March 2023 / Published online: 30 March 2023

Abstract Investigating factors affecting students' academic performance seems a hard job for researchers on the empirical front. Beliefs, parents' educational background, motivation, and attitudes have been proven significantly influence achievement. However, concurrent research on the relationship among these variables seems scarce. Therefore, to contribute to this gap in knowledge, the purpose of this study is to examine the structural relationships among beliefs, parents' educational level, attitude, motivation, and achievement in mathematics learning. We selected 30 classes randomly from six schools in Surabaya, Indonesia. This study involved 894 fifth- and sixth-grade students (448 boys and 446 girls). Structural equation modeling results showed that this model predicts students' achievement in mathematics ($R^2 = 0.49$). Beliefs are positively associated with students' achievement ($\beta = 0.20$, $p < 0.001$), attitude ($\beta = 0.82$, $p < 0.001$), and motivation ($\beta = 0.68$, $p < 0.001$). Parents' educational level is positively associated with achievements ($\beta = 0.17$, $p < 0.001$) and motivation ($\beta = 0.07$, $p = 0.04$). Beliefs were indirectly associated with achievements through attitude ($\beta = 0.31$, $p < 0.001$) and motivation ($\beta = 0.08$, $p = 0.01$). The indirect association between parents' educational level and achievement through motivation was insignificant. This study is valuable because it helps unpack the relationship between beliefs, parents' educational level, attitudes, motivation, and achievement.

Keywords Belief · Parents' Education · Attitude · Motivation · Achievement

Introduction

Although researchers and mathematics educators have been attempting to identify the most influential factors behind mathematics research for many years, the role of the factors behind students' mathematics performance remains unclear. Obviously, cognitive factors solely are not enough to explain the phenomena behind academic performance. Therefore, investigations that combine cognitive, metacognitive, and non-cognitive factors may fill this research gap. According to the metacognition knowledge theory (Csíkos et al., 2011; Veenman et al., 2006), those who can regulate and judge beliefs about mathematics will succeed in academic performance. Those who succeed in academics have good motivation (Middleton & Spans, 1999; Habók et al., 2020), and a positive attitude toward mathematics (Casty et al, 2021; Kiwanuka et al., 2022). While the social cognitive theory suggested that students' success in academic learning is determined by learning experience and environmental stimuli (Bandura, 2001). Driven by both theories, researchers have suggested that students' beliefs (Hidayatullah & Csíkos, 2022; Hofer, 2000; Schommer-Aikins et al., 2005), motivation (Habók et al., 2020; Pajares & Graham, 1999), attitude (Kiwanuka et al., 2022; Mazana et al., 2018), and parents' educational level (PED; Dixson et al., 2018), play a critical role in students' mathematics performance.

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In the literature review, empirical studies proved that beliefs as part of metacognition were consistently associated with mathematics achievements (Hidayatullah & Csíkos, 2022; Hofer, 2000; Schommer-Aikins et al., 2005). For instance, a study by Schommer-Aikins et al. (2005) suggested that what students perceive about the nature of mathematics affects their achievement. Students tend to fail academically when they think that mathematical tasks can be solved very quickly. Moreover, research also indicated that beliefs are not only associated with achievements but also it is associated with attitudes and motivation (Hofer, 2000; Rarujanai et al., 2022). Fishbein (1963) pointed out that attitude is a function of personal beliefs. In other words, personal beliefs are a source of information that generates individual motivation attitudes toward mathematics and in turn, influences mathematics achievements.

At the same time, academic performance and motivation were also closely associated with a personal background like parents' educational background (PED). According to prior research (Cascella, 2020; Davis-Kean, 2005), PED is consistently associated with students' mathematics performance. Students with a higher level of PED tend to have better achievements (Dixson et al., 2018) because parents with high educational backgrounds tend to be more involved in their children's studies. Besides, research indicated that PED determines students' academic motivation. For instance, a study by Acharya and Joshi (2009) suggested that students who come from high PED levels are more motivated than those students whose PED levels are less.

Although there was evidence indicating achievements are associated with beliefs and PED, little is known whether beliefs and PED can also predict and control attitudes and motivation, especially in mathematics learning. Moreover, less attention has been directed to the mediation of attitudes and motivation for the relationship between beliefs, PED, and achievements in mathematics learning. Therefore, investigating the interrelation among these variables in the mathematics learning context is imperative.

To respond to the gap in the previous studies, the aim of this study is to examine how beliefs and PED are associated with attitudes and motivation and predict students' achievements in mathematics learning. We develop a model that examines the structural association among beliefs, PED, attitudes, motivation, and achievement in mathematics learning. We study whether attitude and motivation mediate beliefs and achievement and whether motivation mediates the relationship between PED and achievement.

Theoretical Framework

Role of Beliefs About Mathematics in Achievement, Attitudes, and Motivation Towards Mathematics

Schoenfeld (1985) defines beliefs about mathematics as someone's worldview about mathematics. Based on this definition, beliefs about mathematics may constitute the perception of the nature of mathematics, problem-solving, teaching mathematics, etc. Empirical study has proved that beliefs influence mathematics achievement. Csíkos et al. (2011) suggested that students tend to follow their beliefs about the nature of mathematics when solving mathematical tasks, such as the perception that all word problems can be solved by applying arithmetic operations. Students who believe that all word problems can be solved using text information tend to solve such problems using superficial approaches. In their empirical study, Hidayatullah and Csíkos (2022) found that students' beliefs about their competence in mathematics significantly influence their achievement.

Empirical studies suggested that beliefs play a key role in shaping individual attitudes. Personal beliefs have been recognized as informational bases that determine attitude and form individual behavior (Rarujanai et al., 2022). Savolainen et al. (2022) reported that beliefs had a strong effect on individuals' attitudes. Fishbein (1963) emphasized that an individual's attitude toward an object is a function of their beliefs about the object. Prior research (Muis & Foy, 2010; Muis et al., 2006) also indicated the links between beliefs and motivation. Kim and Keller (2010) empirically identified a significant influence of students' beliefs on their motivation toward mathematics. Habók et al. (2020) suggested that when students hold strong beliefs about their capability, they have good motivation to achieve the best performance. Therefore, the influence of beliefs on achievement, attitude, and motivation is investigated in the present study.

Role of Parents' Educational Background in Mathematics Achievements and Motivation

An increase in the SES of students, such as parents' education level (PED) and working status, family income, and home opportunities, induces a positive change in their educational outcomes (Suna, 2020). Students with Low-PED levels tend to show poorer academic performance than students whose high-PED level (Acharya & Joshi, 2009). Parents with a high level of education tend to be more active to support their children's studies (Tan et al., 2020), and in turn, it would affect their children's performance in mathematics. In the previous studies, the PED level was also associated closely with students' motivation. Ruedas-Gracia et al. (2020) pointed out that PED influences motivation

indirectly through the mediation of school belonging. Students who come from high PED levels tend to have more motivation since their parents support their children academically. Therefore, students were more motivated to study. However, a further empirical study is needed for clarity due to the scarcity of literature resources describing the relationship between PED, motivation, and achievement.

Attitude as a Mediator of the Relationship Between Beliefs and Achievements

Attitude is an individual disposition or tendency to respond positively or negatively to an object, situation, or another person (Segarra & Juliá, 2021; Harun, 2021; Di Martion & Zan, 2011; Hannula et al., 2016; Kiwanuka et al., 2022). Attitude toward mathematics is also perceived as the liking and enjoyment of and interest in mathematics; it can also mean the opposite of these feelings, which in extreme cases include "math phobia" (Ernest, 1989; Grootenboer & Marshman, 2016) and a combination of affective feelings and cognitive beliefs.

As we discussed earlier, there is a link between attitudes and beliefs. Fishbein (1963) emphasized that one's attitude toward any object is a function of his/her beliefs about the object. If students hold strong beliefs about mathematics, they will hold positive feelings toward mathematics. Several studies have recorded the association between attitudes and beliefs. Chan and Lay (2021) pointed out that students' behavior in the classroom contexts was influenced by their personal judgment about their capability. Another study by Ünlü et al. (2010) suggested that the more positive individuals' attitudes toward mathematics, the stronger their beliefs. Furthermore, previous studies suggested attitude plays a significant role in the mathematics learning (Kiwanuka et al., 2022; Palacios et al., 2014). Ma (1997) and Mazana et al. (2018) reported the critical role of attitudes on mathematics achievement. The researchers stated that students' feelings about mathematics learning, such as enjoyment influent, directly affect their achievement; in particular, feelings of difficulty influence their achievement. As a result, we proposed that attitudes may serve as a mediator in the relationship between beliefs and achievements.

Motivation as a Mediator of the Relationship Between Beliefs and Achievements

Motivation is the factors and the process that drive and govern the interest, intensity, and quality of goal-directed behavior (Paulsen & Feldman, 1999). Motivation deals with interest, engagement, and attention, which directly and indirectly influence students' cognitive process, learning process, construction of tasks, and problem-solving (Hardré, 2011). Based on this definition, motivation plays a key role in driving students' learning activities.

The role of motivation in mathematics learning has been extensively researched. An international survey by PISA showed an association between students' motivation and performance. Students with higher motivation achieve higher scores (Mo, 2019). Herges et al. (2017) suggested the positive influence of motivation on students' achievement. When students are motivated, they will put effort into doing well in academic performance. According to prior research, motivation is also associated with beliefs about an object. Paulsen and Feldman (1999) pointed out that motivation correlates positively with students' beliefs. The more students hold sophisticated beliefs about knowledge, the higher their intrinsic motivation. Voica et al. (2020) suggested that the level of students' motivation in mathematics is determined by their individual beliefs. Students' beliefs strengthen and stimulate their motivation in mathematics. Therefore, there is the possibility that motivation may mediate the association between beliefs and achievements.

Motivation as a Mediator of the Relationship Between PED and Achievements

As we discussed earlier, some research suggested motivation was associated with achievements. Herges et al. (2017) reported that students with high motivation tend to have better achievements in mathematics. Mo (2019) suggested that when students become motivated, their anxiety in math decreased. Then, students will enjoy mathematics learning and put effort into studying, affecting their performance. At the same time, there were pieces of evidence that showed motivation is also associated with PED. Acharya and Joshi (2009) suggested that students with parents with post-graduate education levels have more motivation compared to students with high school education parents. Iwaniec (2020) found students whose parents have a lower level of education tend to be less motivated in academic learning. Therefore, in the present study, we proposed that motivation can mediate PED and achievements.

Research Aims and Hypothesis Model

As mentioned above, previous studies suggested that beliefs, PED, attitudes, and motivation play a key role in mathematics achievements. Our focus is to investigate the prediction of beliefs and PED on achievements. Also, we examine the mediation of attitudes and motivation for the relationship between beliefs, PED, and achievements. Figure 1 described our proposed model. Our investigation follows the hypothesis:

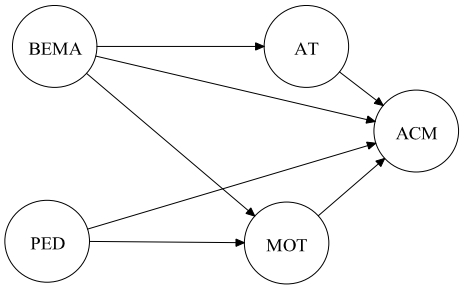

Fig. 1 Hypothesis model of the association between beliefs (BEMA), PED, attitude (ATM), motivation (MOT), and achievement (ACM)

H1: Beliefs are expected to be positively associated with attitudes, motivation, and mathematics achievements.
H2: PED is expected to be positively associated with motivation and mathematics achievements.
H3: Attitude mediated the association between beliefs and mathematics achievements.
H4: Motivation mediated the association between beliefs and mathematics achievements.
H5: Motivation mediated the association between PED and achievement.

Method

Participants

This study was conducted in Surabaya, an urban area and the capital city of the province of East Java, Indonesia. A total of 894 students aged 9–12 years participated in this study. We selected 30 classes randomly from five schools in Surabaya. They were from the fifth grade (449) and the sixth grade (445) and consisted of 448 boys and 446 girls (Table 1). Data were collected via a survey study based on the paper–pencil test system. The students in this study come from various socio-economic status backgrounds because Indonesian schools use a zoning system that ensures a short distance between each school and its students' homes. Table 1 describes the demographics of our participants.

Table 1 Demographics of participants

Characteristic	Full sample	Percentage
Gender		
Boys	448	50.1
Girls	446	49.9
Grade		
Fifth	449	50.2
Sixth	445	49.8
Age		
9 years	15	1.7
10 years	316	35.3
11 years	417	46.6
12 years	146	16.3

Instruments

Beliefs about mathematics education. We selected 9 items from the mathematics-related beliefs system questionnaire developed by Eynde and De Corte (2003) to measure students' beliefs about mathematics, such as "I can understand the difficult topic presented in mathematic" and "My teacher tries to make learning mathematics interesting." These items were rated using a 5-point Likert scale (1 = strongly disagree, 5 = Strongly agree). We confirmed the validity by performing CFA with a maximum likelihood parameter estimate (Table 2). The result showed that the model of beliefs about mathematics education instrument is fit, CFI = 0.94, TLI = 0.91, RMSEA = 0.06, and SRMR = 0.04. The Cronbach's alpha values ($\alpha = 0.86$) showed that our instruments had good internal consistency.

Attitudes towards mathematics. We adapted four items of attitudes toward mathematics questionnaire (Al-Mutawah & Fateel, 2018). For instance, "I learn many interesting things in mathematics" and "Mathematics is harder for me than any other subject". These items were rated using a 5-point Likert scale (1 = Strongly disagree, 5 = Strongly agree). We found a fit model for attitude toward mathematics instruments, CFI = 0.99, TLI = 0.97, RMSEA = 0.06, SRMR = 0.02. The corresponding questionnaire was reliable ($\alpha = 0.75$).

Motivation towards mathematics. We measured students' motivation with five items, such as "I want top grades in mathematics learning" and "Whatever I do, I want to be the best in mathematics learning." We rated these items with a 5-point Likert scale (1 = strongly agree, 5 = strongly disagree). Each item in this questionnaire had a high coefficient alpha. The model of motivation toward mathematics had a good fit model (CFI = 0.99, TLI = 0.97, RMSEA = 0.06, SRMR = 0.02) and a reliability value of 0.082 ($\alpha = 0.82$).

Parents' education level (PED). The data were collected by asking students what their fathers' and mothers' highest education level were. We calculated the PED by the sum of the father and mother's educational levels. The range of

Table 2 Validity and reliability of beliefs, attitudes, and motivation

Variable	CFI	TLI	RMSEA	SRMR	Alpha
Beliefs about mathematics	0.97	0.95	0.06	0.03	0.86
Attitude toward mathematics	0.99	0.97	0.06	0.02	0.77
Motivation toward mathematics	0.99	0.97	0.06	0.02	0.80

the father and mother's educational level from 1–7 (1 = no experience education, 2 = primary education, 3 = secondary education, 4 = senior high school, 5 = higher education (bachelor), 6 = Higher education (Master), 7 = Higher education (doctoral)) following the education systems in the Indonesian context. *Mathematics achievement* data were collected based on students' self-reports about their last score test. The score ranges from 1–100.

Procedure

Since schools in Indonesia have reopened and started conducting offline classes, we collected our data using paper–pencil tests to obtain good responses from the students. Data gathering was completed in the middle of an academic semester. In the first step, we prepared our instruments, which were then checked by experts. We communicated with the schools' principals and sent letters to obtain permission. We also consulted the mathematics teachers in all the schools regarding the ethics of our data collection (the data-gathering process involved these teachers). They helped further enhance our method and complete the questionnaires. The students were asked to complete the survey within at least two weeks to avoid fatigue.

Data Analysis

In the first step, we examined the construct validity and reliability of each questionnaire. We used SPSS and MPlus8 software versions. Confirmatory factor analysis (CFA) was used to examine construct validity. The Tucker–Lewis index (TLI), comparative fit index (CFI), and root mean square error of approximation (RMSEA) were used to assess the model fit. Hu and Bentler (1999) suggested cutoff criteria of close to 0.095 for TLI and CFI and <0.05 or 0.6 for RMSEA. According to van de Schoot et al. (2012), TLI and CFI ≥ 0.9 and RMSEA ≤0.08 are acceptable. Maximum likelihood (ML) parameter estimates and an absolute value of 0.4 were used in this study. Afterward, we examined the internal consistency, or reliability, of each questionnaire. In the second step, we studied the direct influence of all noncognitive factors on achievement and the former's prediction of the latter. In the third step, we performed descriptive statistical analysis to describe our data (mean and standard deviation [SD]) and the correlation between factors. Hemphill (2003) said that coefficient correlation values below 0.2, between 0.2 and 0.03, and more than 0.3 indicate low, medium, and high correlation, respectively. We examined our hypothesis model via full structural equation modeling (SEM) in the third step. The model fit criteria were the same as those for the CFA (TLI and CFI ~ 0.95, RMSEA ≤ 0.08).

Result

Descriptive Statistics and Correlation of Latent Variables and Achievement

Table 3 describes the descriptive statistics and correlation between the latent variables and achievement, along with their statistical means and SDs. Most of the participants came from high parent educational backgrounds as shown by the mean result (M = 4.67, SD = 1.00). The data also showed that most of the students hold strong beliefs (M = 3.76, SD = 0.57), have positive attitudes (M = 3.82, SD = 0.68), have a good motivation (M = 3.67, SD = 0.67), and have good score in math (M = 86.17, SD = 6.21).

With respect to the correlation among latent variables, the results showed that all the correlations among variables were significant. The correlations between parents' educational background, achievement, and other latent variables were significant. Beliefs about mathematics education and motivation had the highest peer correlation ($r = 0.68$). Attitudes were significantly correlated with PED ($r = 0.30$) and beliefs about mathematics ($r = 0.64$). Motivation was strongly correlated with attitude ($r = 0.67$). Motivation was also correlated with PED ($r = 0.30$). Overall, achievement and all noncognitive factors had a strong correlation with each other (Hemphill, 2003).

SEM Analysis

The association between the latent variables was analyzed by covariance-based structural equation modeling (CB-SEM) using the software *Mplus version 8*. First, we examined the

Table 3 Descriptive statistics and correlations of beliefs, attitude, motivation, PED, and achievement

Variable	Mean	SD	Min	Max	1	2	3	4
1. Parents education (PED)	4.67	1.00	1.00	7.00				
2. Beliefs in math	3.76	0.57	1.00	5.00	0.27**			
3. Attitude towards math	3.82	0.68	1.00	5.00	0.30**	0.64**		
4. Motivation in math	3.67	0.67	1.00	5.00	0.30**	0.68**	0.67**	
5. Achievement	86.17	6.21	39.00	100.00	0.45**	0.57**	0.58**	0.60**

**Correlation is significant at the level 0.001 ($p < .001$)

model hypotheses (Fig. 1). We found the model fit of the first hypothesis, Chi-square = 573.87 $df = 182$, $p < 0.00$, CFI = 0.95, TLI = 0.94, RMSEA = 0.04, SRMR = 0.04 (Hu & Bentler, 1999; van de Schoot et al., 2012), but not all relations were significant ($p > 0$; Fig. 2). Overall, this model could explain the students' mathematics achievement 49% ($R^2 = 0.49$).

The path analysis coefficient values showed that all model variables significantly influenced students' achievement. Beliefs about mathematics were positively associated with students' achievement (β = 0.20, $p < 0.001$), attitude (β = 0.82, $p < 0.001$), and motivation (β = 0.68, $p < 0.001$). The achievement was positively and directly related to attitude (β = 0.38, $p < 0.001$) and motivation (β = 0.11, $p = 0.01$). Beliefs were positively and indirectly related to students' achievement (β = 0.31, $p < 0.001$) through attitude toward mathematics. In other words, attitude partially mediated the relationship between beliefs about mathematics and achievement. Beliefs were also indirectly associated with achievement (β = 0.08, $p = 0.01$) through motivation. PED was positively associated with achievement (β = 0.17, $p < 0.001$). The direct association between PED and motivation was significant but weak (β = 0.07, $p = 0.04$). However, the indirect association between PED and achievement through motivation was insignificant (β = 0.01, $p = 0.11$).

We further examined the model in Fig. 3 for the fifth and sixth grades. The models for both grades had a good fit (fifth grade: CFI = 0.94, TLI = 0.932, chi-square = 404.96, df = 182, $p < 0.00$, RMSEA = 0.05, SRMR = 0.05; sixth grade: CFI = 0.95, TLI = 0.94, chi-square = 388.28, df = 182, $p < 0.00$, RMSEA = 0.05, SRMR = 0.04). Although both models had a good fit, some associations were not significant. The direct effect of beliefs on achievement was only significant for the fifth grade. Nonetheless, for both models, beliefs significantly influenced achievement via attitude.

Beliefs were positively associated with motivation and attitude in both grades. The association between beliefs and achievements was stronger in fifth grade than in sixth grade. PED was also associated with achievement in both grades. A stronger association between PED and motivation was shown in the sixth grade. The links between PED and motivation were only significant in sixth grade. The mediation of attitude for beliefs and attitudes was significant in both grades. However, the mediation of motivation for the relationship between the two was only significant in sixth grade. While the mediation motivation for the relations of PED and achievements in both grades was not significant.

Discussion

The novelty of this research lies in the proposed structural model consisting of students' beliefs, PED, attitudes, motivation, and achievement, which have been rarely investigated.

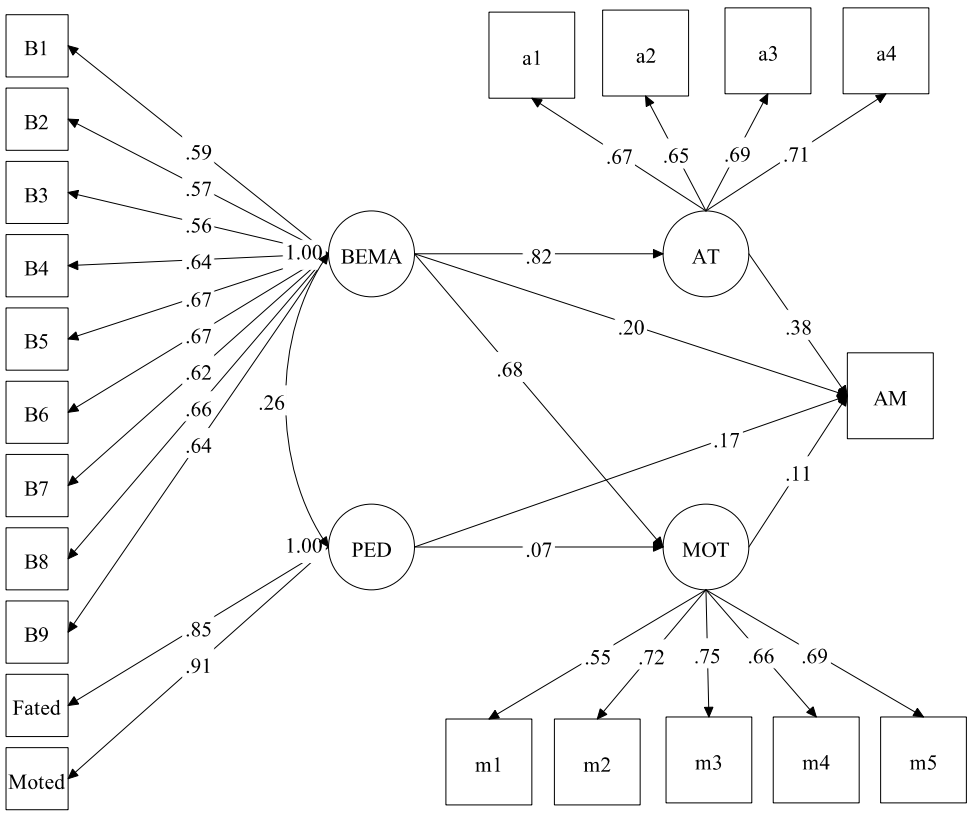

Fig. 2 Standardized path coefficient of the relationship between beliefs (BEMA), PED, attitude (AT), motivation (MOT), and achievement (AM)

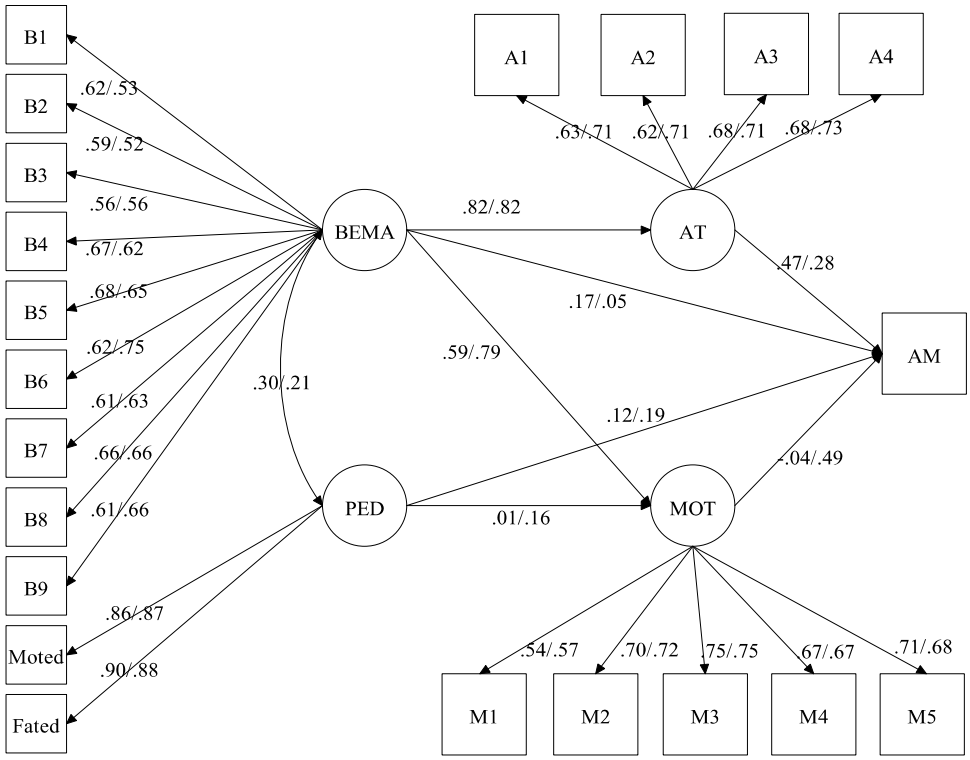

Fig. 3 Standardized path coefficient of relationships between beliefs (BEMA), PED, attitude (AT), motivation (MOT), and achievement (AM) for fifth and sixth grades

Remarkably, the simultaneous contribution of all the variables (beliefs, attitude, motivation, and PED) explains mathematics achievements by 49%. Also, we find the mediation of attitudes and motivation for the association of beliefs, and achievements. Hence, these variables are important in determining students' performance.

First, our research confirmed that beliefs about mathematics are associated with mathematics achievement, attitude, and motivation. This finding supports Hypothesis 1, which holds that beliefs are associated with achievements, attitudes, and motivation.Interestingly, the direct association between beliefs and attitudes is the strongest relation among other variables (motivation and achievements). It means that students' beliefs about mathematics would drive their attitudes toward an object (Kim & Keller, 2010), which may affect their achievements (Csíkos, 2011; Verschaffel et al., 1994). This finding is in line with the prior research (Caprara et al., 2003; Rarujanai et al., 2022), which consistently indicated the association between the two. Those who have lower-level beliefs tend to have negative attitudes and low achievements. Moreover, we found that motivation toward mathematics is also determined by students' beliefs about mathematics. This finding confirmed the prior studies (Kim and Keller (2010); Muis & Foy, 2010; Muis et al., 2006) which indicated that the conception of mathematics, like perceiving that the most difficult mathematical tasks can be understood, will increase students' motivation to gain the best score in math. Among latent variables, attitudes toward mathematics are the strongest factors directly associated with achievements in mathematics.

Secondly, the data showed that PED predicts achievement and motivation. This finding supports Hypothesis 2, which stated that PED is expected to be positively associated with achievements and motivation. This result is consistent with previous studies (Acharya & Joshi, 2009) that PED predicted achievement. The level of PED background may relate to their involvement in mathematics learning, like providing support for students. Although this finding is also consistent with the previous study (Acharya & Joshi, 2009; Iwaniec, 2020) that suggested PED determines individual motivation, the association between the two was weak. A possible explanation of the weak association between PED and motivation is that PED is just one of the several factors that influence students' motivation. Other factors probably affect students' motivation, such as parents' involvement in students' learning.

Thirdly, we found an indirect association between beliefs and achievements through the mediation of attitudes toward mathematics. This result supports Hypothesis 3, which stated that attitude mediated the association between beliefs and achievements. This finding is in line with the prior research (Chan & Lay, 2021; Ünlü et al., 2010) that consistently stated that beliefs are associated with attitudes. This finding also supports the thesis proposed by Fishbein (1963), who explained that students' attitude toward an object (mathematics education in this

study) is a function of their beliefs about the object. We assume that student's achievements are affected by their attitudes such as enjoyment which is controlled by their beliefs about mathematics.

Fourthly, we found an indirect association between beliefs and achievements through motivation toward mathematics. This finding supports Hypothesis 4, which holds that motivation mediates the association between beliefs and achievements. It means that when students perceive that they are capable of mathematics, it would control their motivation (Muis & Foy, 2010; Muis et al., 2006) and then affect achievements (Herges et al., 2017; Mo, 2019). According to House (2006), the extent to which students believe in math would drive their effort, such as hard work, which helps them achieve high scores in mathematics.

Fifthly, according to Hypothesis 5, motivation will be expected to mediate the relationship between PED and achievements. In the present study, the mediation of motivation for the two variables was not significant. The data in the present study showed that PED does not associate with motivation, which is contrary to prior studies (Ruedas-Gracia et al., 2020; Steinmayr et al., 2012). Also, motivation does not mediate the relationship between PED and achievements. A possible explanation is that previous studies did not control other variables when investigating the relationship between PED and motivation. Another explanation may be that PED only has a marginal influence in this model.

Unexpected differences emerge between the fifth and sixth grades. The influence of beliefs on motivation and attitude is significant for both grades. By contrast, beliefs only significantly influence fifth-grade students' achievement. A possible reason is that sixth-grade students may become more rational in their beliefs about mathematics because their mental process is more mature than those of younger students. Therefore, the responses of the sixth-grade students to the questionnaire about the belief systems imply a low significance of the influence of beliefs on achievement. However, we cannot generate any conclusion because of the cross-sectional nature of this study. A longitudinal study would affirm these factors' prediction of students' achievement.

To summarize, the finding of this study pointed out that the direct relation of beliefs on attitudes towards mathematics was the strongest direction among other associations. Attitudes are the strongest predictor for students' achievements among other variables latent (beliefs, motivation, and PED). While motivation is the weakest predictor of achievements in the present study. This finding told us that the direct association between PED and achievements was significant. Also, our study told us that attitudes and motivation can mediate the relationship between beliefs and achievement. However, motivation did not mediate the relationship between PED and achievements.

Limitations and Suggestions for Future Research

Although this finding provided a wealth piece of information, several limitations should be noted. In the present study, we only use cross-sectional surveys. This means the regression coefficients in our path models cannot be interpreted as the causal relationship among beliefs, PED, attitudes, motivation, and achievements. A longitudinal study is required for future research to prove the predictive power of the aforementioned variables for achievement. Furthermore, we only used the PED variable as an external factor to explain achievements. At present, parents' education is not the sole factor that influences students' achievement and motivation. Family income and learning support tools, such as appliances, mathematics, and digital devices, may also affect students' perception of mathematics. Therefore, future works should expand student backgrounds, such as SES, that incorporated family income. Other variables, such as self-regulated learning and students' attitude toward digital technology in mathematics, should likewise be investigated in future research.

Implications

This study has significant findings for mathematics education. For practice, considering the mediation of attitudes and motivation for the relationship between beliefs and achievements, mathematics educators should consider how to shape students' beliefs, because these beliefs would control students' attitudes as well as motivation, in that way their achievements will increase. Mathematics educators should train students on how to regulate their motivation as well as their attitudes toward mathematics. Additional support services can be provided by mathematics educators to improve students' achievements by communicating with parents on how to encourage parents to increase their involvement. Mathematics educators should pay attention more to students with low parents' educational levels. Preservice teachers can use this finding as an academic discourse to be analyzed from a different perspective.

Acknowledgements This research was supported by the MTA-SZTE Metacognition Research Group. We wish to say thanks to Ravista Devianti, Nang Kham Thi, and Listiani for their helpful comments on earlier of draft of this paper. The first author of this paper is a recipient of the Hungarian government Stipendium Hungaricum Scholarship in collaboration with Indonesian Government.

Funding Open access funding provided by University of Szeged.

Declarations

Conflict of Interest The author(s) have stated no potential conflict of interest.

Availability of Data and Material Applicable.

Code Availability Applicable.

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