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Exploring Parental Involvement, Beliefs, and Student Self-Regulation in Online Mathematics Learning: A Multivariate Analysis

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Abstract. Parents' involvement and beliefs in their children's learning are external factors which can influence students' online mathematics learning experiences and success. Student self-regulation, encompassing the capacity to monitor, seek feedback, and reflect on learning, plays a crucial internal role in success of learning mathematics online. This study employed multivariate analysis to examine the complex relationships among parental involvement (control and support), parental beliefs (instrumental and relational), and student self-regulation in online mathematics learning. The participants were 125 upper elementary students (grades 4–6, ages 9–12) and their mothers from Yogyakarta, Indonesia. Students completed measures of perceived parental involvement and self-regulation; whereas, mothers reported their beliefs about mathematics learning. Exploratory factor analysis has revealed a two-factor structure for self-regulation, that is, feedback-seeking behavior and self-reflection, while confirmatory factor analysis has validated the two-dimensional structures of parental involvement and beliefs. Meanwhile, path analysis indicates that parental support fully mediated the relationship between instrumental beliefs and self-reflection (β = 0.135, p = 0.038), thus indicating that instrumental beliefs enhance reflective capacity specifically through supportive behaviors. Both control and support strongly predict self-reflection (β = 0.471 and 0.645, respectively, both $p < 0.001$). Relational beliefs negatively predict FSB (β = -0.210, p = 0.026). Moderation analysis has revealed no

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significant interaction between parental beliefs and involvement. Covariate analysis has shown a significant gender difference in perceived parental beliefs ($p = 0.029$), with females reporting higher levels than males. The findings highlight the importance of examining specific dimensions of parental involvement and beliefs, and suggest that interventions should focus on helping parents translate instrumental beliefs into supportive behaviors that foster students' reflective capacity in online mathematics learning.
Keywords: Parental involvement; parental beliefs; student self-regulation; online mathematics learning.

Tėvų įsitraukimo, įsitikinimų ir mokinių savireguliacijos mokantis matematikos internetu tyrimas: daugiamatė analizė

Santrauka. Tėvų įsitraukimas ir įsitikinimai apie vaikų mokymąsi yra išoriniai veiksniai, kurie gali turėti įtakos mokinių patirčiai ir sėkmei mokantis matematikos nuotoliniu būdu. Lemiamą vaidmenį sėkmingam matematikos mokymuisi nuotoliu atlieka mokinių savireguliacija, apimanti gebėjimą stebėti savo pažangą, siekti grįžtamojo ryšio ir reflektuoti mokymąsi. Šiame tyrime, pasitelkiant daugiamatę analizę, buvo tiriamos sudėtingos tėvų įsitraukimo (kontrolės ir paramos), tėvų įsitikinimų (instrumentinių ir santykių) bei mokinių savireguliacijos mokantis matematikos nuotoliniu būdu sąsajos. Tyrime dalyvavo 125 vyresniųjų pradinių klasių mokiniai (4–6 klasės, 9–12 metų amžiaus) ir jų motinos iš Jogjakartos miesto Indonezijoje. Mokiniai užpildė klausimynus, skirtus suvokiamam tėvų įsitraukimui ir savireguliacijai įvertinti, o motinos pateikė savistatas apie savo vaikų matematikos mokymąsi. Tiriamoji faktorinė analizė atskleidė, kad savireguliaciją sudaro du faktoriai, grįžtamojo ryšio siekiantis elgesys ir savirefleksija, o patvirtinamoji faktorinė analizė pagrindė dvimates tėvų įsitraukimo ir įsitikinimų konstruktų struktūras. Takų analizė atskleidė, kad tėvų parama medijuoja ryšį tarp instrumentinių įsitikinimų ir savirefleksijos ($\beta = 0{,}135$, $p = 0{,}038$), ir tai rodo, kad instrumentiniai įsitikinimai stiprina refleksijos gebėjimus palaikančiu elgesiu. Tiek kontrolė, tiek parama stipriai prognozuoja savirefleksiją (atitinkamai $\beta = 0{,}471$ ir $0{,}645$, abu $p < 0{,}001$). Įsitikinimai apie santykius neigiamai prognozuoja grįžtamojo ryšio siekiantį elgesį ($\beta = -0{,}210$, $p = 0{,}026$). Moderacinė analizė neatskleidė reikšmingos tėvų įsitikinimų ir įsitraukimo sąveikos. Kovariacijos analizė leido nustatyti reikšmingą lyčių skirtumą pagal tėvų įsitikinimus ($p = 0{,}029$) – mergaitės surinko aukštesnius įverčius nei berniukai. Šie rezultatai rodo, kaip svarbu tirti konkrečius tėvų įsitraukimo ir įsitikinimų aspektus bei tai, kad intervencijos turėtų būti skirtos teikti pagalbą tėvams siekiant, kad instrumentiniai įsitikinimai virstų palaikančiu elgesiu, kuris skatintų mokinių refleksijos gebėjimus mokantis matematikos nuotoliniu būdu.
Pagrindiniai žodžiai: tėvų įsitraukimas, tėvų įsitikinimai, mokinių savireguliacija, matematikos mokymasis nuotoliniu būdu.

Introduction

During the COVID-19 pandemic, online learning became a widely adopted alternative mode of instruction, and its implementation has continued beyond the pandemic period (Betthäuser et al., 2023; Spitzer & Musslick, 2021). Online learning refers to a learning process conducted via the internet, in synchronous and asynchronous formats, in which, interaction among students, teachers, and peers occurs at agreed-upon times and locations (Singh & Thurman, 2019). Some parents rejected online learning because it did not meet their expectations for K–12 instruction. They reported that children often struggled with self-management, whereas, grandparents, who served as primary caregivers in some families, often lacked the time and knowledge required to support online learning effectively (Dong et al., 2020).

In mathematics education, online methods provided alternative learning options that enabled educational activities to be conducted more flexibly, particularly in homeschooling contexts (Spitzer & Musslick, 2021). Online mathematics learning offered a way to deliver instruction remotely and provided flexibility as well as access to resources that might not otherwise be available in traditional classrooms. However, the success of online mathematics learning has not been conclusively established, as multiple factors influence learning outcomes. One important internal factor that influences students' success in mathematics is self-regulated learning (Hasibuan et al., 2019; Pratama et al., 2017). Student self-regulated learning refers to the capacity to learn independently while remaining engaged with teachers and peers (Hasibuan et al., 2019). The characteristics of self-regulated learning include students' efforts to improve their competence independently, reduced reliance on external direction, and engagement in self-evaluation and reflection (Agustina & Fajar, 2018).

In addition to internal factors, external factors also influence students' experiences and success in online mathematics learning. One important external factor is parental involvement in children's learning activities (Bubić et al., 2020). Parental involvement in children's learning has been recognized as a factor that supports and influences academic achievement (Afolabi, 2014; Crosnoe, 2009; Wilder, 2014). Research has consistently suggested that parents play a pivotal role in supporting children's academic outcomes, particularly in non-traditional learning environments such as online education (Lee, 2022). Parental involvement is relevant both in local contexts and as a recognized global component of children's education. To support their children's success in online learning, parents can provide a conducive learning environment at home, establish strong communication with teachers, and actively participate in virtual school activities (Hertel & Jude, 2016). Collaboration among parents, teachers, and school administrators has been shown to enhance children's motivation and academic achievement (Grolnick & Pomerantz, 2022). In addition, parental involvement in education has been associated with reducing educational disparities (Crosnoe, 2009).

Parental involvement in online mathematics learning is considered a critical determinant of student success. The effectiveness of online mathematics instruction is influenced by parental engagement in cognitive, emotional, social, and pedagogical support (Purnomo et al., 2022). By providing a supportive home learning environment, parents can foster students' mathematical skills and independent learning habits. Actively involved parents can enhance children's motivation, improve mathematical competence, and facilitate the exploration of mathematical concepts. These factors contribute to the development of self-regulated learning and improved academic achievement (Grolnick & Pomerantz, 2022; Hertel & Jude, 2016; Zulfiqar et al., 2023). Moreover, raising awareness of parental involvement in academic activities is essential for maintaining supportive parent–child relationships (Parmar & Nathans, 2022).

Parents' beliefs, expectations, and prior experiences are additional external factors that contribute to children's academic achievement (Afolabi, 2014). Parents' beliefs about their children's learning, reflected in their level of involvement and interactions, have been shown to influence children's academic motivation (Lerkkanen & Pakarinen, 2019). Research indicates that strong parental beliefs in academic success, particularly in mathematics, play an important role in shaping the resources parents allocate to support learning. For example, those parents who strongly value mathematics tend to have children who demonstrate more advanced mathematical skills (Silver et al., 2021). These beliefs often translate into tangible actions, such as providing additional mathematics learning materials and structured practice opportunities (Purnomo et al., 2022). Furthermore, parental beliefs in the educational process can strengthen the partnership between school and home and support children's motivation to study mathematics (Lerkkanen & Pakarinen, 2019).

Several studies have examined parental involvement and beliefs regarding children's academic success. Parental involvement and beliefs have been found to influence educational attainment significantly (Nguyen et al., 2022). Afolabi (2014) argued that, although parental involvement is an important strategy in determining academic success, some empirical studies have questioned its impact due to measurement challenges. In addition, not all parents have expressed willingness to be actively involved in their children's education, as some perceived that the primary responsibility for education lies with schools (Dinallo, 2016). Furthermore, Barger et al. (2019) and Boonk et al. (2018) reported that different types of parental involvement do not produce uniform effects on student achievement. These findings highlight the complex nature of parental involvement. Not every form of engagement yields consistent outcomes. Therefore, further investigation is needed to clarify the relationship between parental involvement, parental beliefs, and students' self-regulation in the context of online mathematics education.

The novelty of this study lies in its exploration of the complex relationships among parental involvement, parental beliefs, and students' self-regulation in online mathematics contexts. This study employs mediation and moderation analyses to examine how these variables interact and influence student outcomes. Mediation analysis examines whether parental involvement functions as a mechanism through which parental beliefs relate to students' self-regulation (Purnomo et al., 2022). For example, higher levels of parental involvement may foster stronger self-regulation, which, in turn, may enhance mathematics achievement. Moderation analysis examines whether the relationships among these variables vary across demographic characteristics such as gender, age, and grade level. Prior research has suggested that parental engagement may have different effects across student groups (Bubić et al., 2020; Lerkkanen & Pakarinen, 2019). For instance, some studies have indicated that female students may benefit more from parental engagement in certain academic contexts (Bubić et al., 2020). Younger students may also require more direct parental guidance in online learning compared to older students. Understanding mediation and moderation effects can help educators and parents develop targeted strategies to support students' online mathematics learning.

This study aims to provide insight into the way(s) how parental factors influence students' self-regulation in online mathematics settings, which remains relevant in contemporary digital education. The findings are expected to contribute to a deeper understanding of the factors that shape students' self-regulation and to inform the development of more effective educational strategies. Accordingly, the research questions guiding this study are:

1. What is the validity and reliability of the factor structure developed to measure parental involvement, parental beliefs, and students' self-regulation during online mathematics learning?

2. What is the complexity of the mediation relationship among parental involvement, parental beliefs, and students' self-regulation during online mathematics learning?
3. What is the complexity of the moderation relationship among parental involvement, parental beliefs, and students' self-regulation during online mathematics learning?
4. What is the role of covariate variables (gender, age, and grade level) in relation to parental involvement, parental beliefs, and students' self-regulation during online mathematics classes?

Method

Participants

This study involved 125 students from an elementary school in Yogyakarta, ranging from grades four to six, with ages between 9 and 12 years, along with their mothers. This age group was selected because students at this developmental stage begin to engage with more complex and abstract mathematical concepts while simultaneously developing self-regulation skills. Focus on upper elementary students allowed the researchers to examine online mathematics learning within a group that had sufficient cognitive readiness to respond reliably to questionnaire items. Mothers were specifically chosen as the parent respondent because they traditionally serve as the primary facilitators of children's home-based learning, which makes them the most knowledgeable informants regarding children's daily involvement in online activities (Purnomo et al., 2022).

The participants were selected through convenience sampling, while considering accessibility and institutional permission granted to the researchers. This study involved two groups of respondents: 125 students and their mothers. The student data were collected by using an online-based questionnaire administered during the implementation of online mathematics instruction. The data for mothers were collected through a separate online questionnaire distributed via a *WhatsApp* group shared by the classroom teachers. Details of the student participants can be seen in Table 1.

Table 1. *Demographic characteristics of student participants*

Aspect	Category	Sub-Amount	Percentage (%)
Grade	Fourth Grade	46	36.8
	Fifth Grade	40	32
	Sixth Grade	39	31.2
Gender	Male	55	44
	Female	70	56
Age	9 years	27	21.6
	10 years	56	44.8
	11 years	29	23.2
	12 years	13	10.4

Table 1 shows the grade, gender, and age distribution of the participants. The sample consisted of 70 female students (56%) and 55 male students (44%). The distribution across grade levels was relatively balanced. The majority of the respondents were 10 years old (44.8%).

The gender variable reported in Table 1 refers to the child's gender, obtained from student questionnaires. Mothers, who all identified as female, completed separated questionnaires reporting their own parental beliefs.

Informed consent was acquired from the school principal and teachers before data collection. Written parental consent and child assent were obtained for all child participants. All participants were guaranteed anonymity and confidentiality, and they were informed of their right to withdraw from the study at any time without repercussions.

Data Collection and Analysis

In this study, three main instruments were adapted for upper elementary students' online mathematics learning. The adaptation process primarily involved: (1) initial translation contextualization of items in order to reflect on mathematics learning activities; and (2) review by a panel of three experts (two in mathematics education and one in educational psychology) with the objective to assess content validity, clarity, and relevance. All instruments were administered in the Bahasa Indonesia language.

Parental İnvolvement (PI) was measured by using an adapted version of the scale developed by Silinskas and Kikas (2019), who examined parental involvement in mathematics homework and its association with children's performance and motivation. The instrument used in this study was originally developed for elementary students (grade 3 and grade 6) and focused on mathematics-related parental behaviors, making it highly relevant for the present study, which involved a comparable age group. The scale consisted of 8 items, rated on a 4-poin Likert scale, across two dimensions: Perceived Parental Control and Perceived Parental Support, with a reported reliability of 0.90. Perceived Parental Control refers to parents' monitoring and regulation of children's mathematics learning activities, while Perceived Parental Support reflects emotional encouragement and constructive assistance. Although the instrument was initially designed for traditional learning contexts, several items were linguistically modified to ensure their relevance to online learning. For example, references to 'homework' were replaced with 'online mathematics tasks', while maintaining the original construct meaning. These modifications ensure that the instrument remains appropriate for assessing parental behaviors in the context of online learning, specifically for the age group under study. Details of the items are presented in Table 2.

Parental Belief (PB) values were measured by using an adapted version of the Beliefs about Teaching of Mathematics scale, as developed by Purnomo (2017). The researchers had direct access to the original research instrument, which allowed for appropriate adjustments and adaptations to fit the parental context. The original scale was designed to assess teachers' mathematics-related beliefs, including beliefs about the nature of mathematics and mathematics teaching. Although the original instrument targeted teachers, its theoretical framework concerning instrumental and relational orientations toward mathematics was considered conceptually relevant. Therefore, it was adapted to examine parents' beliefs about their children's mathematics learning. In this study, the instrument was completed by mothers as self-report, reflecting their own beliefs about mathematics learning.

Table 2. *Item details of parental involvement instrument*

No.	Dimensions	Number of questions	Question number	Sample item
1.	Perceived parental control	4	1, 2, 3, 4	My parents often interfere when I'm doing online mathematical course
2.	Perceived parental support	4	5, 6, 7, 8	My parents help me with online mathematical course, if I ask them
Total		8		

Instrumental beliefs conceptualize mathematics as a set of rules, procedures, and fixed truths, whereas relational beliefs emphasize understanding, reasoning, and conceptual connections. Based on this framework, 11 items, rated on 6-point Likert scale, were adapted to reflect parents' beliefs about how mathematics should be learned in an online context. The adaptation process was grounded directly in the established theoretical definitions and validated factor structure, as reported in the original study. The items were reconstructed to reflect the parental context while preserving the conceptual meaning of instrumental and relational orientations.

The reliability values reported in the original study for the relevant dimensions ranged between 0.715 and 0.787. The adapted items in the present study retained the original two-dimensional structure. These items were then subjected to confirmatory factor analysis so that to verify their construct validity. All items in this instrument were mathematics-specific, as they explicitly referred to beliefs about mathematics learning rather than general educational beliefs. Details of the items are presented in Table 3.

Table 3. *Item details of parental beliefs instrument*

Dimensions	Number of questions	Question number	Sample item
Instrumental	5	1–5	To excel in mathematics, students must be able to solve problems quickly and accurately.
Relational	6	6–11	An explanation underlying the emergence of mathematical rules and procedures is necessary to understand the meaning of mathematics.
Total	11		

Furthermore, student self-regulation (SR) was measured by using an instrument developed by Yan (2018). The instrument consists of 20 items, rated on 6-poin Likert scale, across four dimensions: Seeking External Feedback Monitoring (SEFM), Seeking External Feedback Inquiry (SEFI), Seeking Internal Feedback (SIF), and Self-Reflection (SR2). Each dimension demonstrated satisfactory reliability coefficients in the original study.

This instrument was selected because it conceptualizes self-regulation as an active process that involves monitoring, feedback seeking, and reflective thinking – i.e., components considered essential for successful learning in online mathematics contexts. The original scale was developed as a domain-general instrument, intended for use across various academic subjects (see Table 4). However, for this study, all items were specifically contextualized to focus on mathematics learning within an online environment. Students reported their self-regulation behaviors in online mathematics learning.

Table 4. *Item details of original student self-regulation instrument*

No	Dimensions	Number of questions	Question number	Example
1.	Seeking external feedback monitoring (SEFM)	5	1-5	I check whether I have mastered the math material by doing additional practice.
2.	Seeking external feedback inquiry (SEFI)	4	6-9	I ask my teacher to provide feedback on what I have done.
3.	Seeking internal feedback (SIF)	4	10-13	My emotions affect my evaluation of my learning achievements.
4.	Self-reflection (SR2)	7	14-20	I think about how deeply others' comments (teachers, family members, and friends) impact my work.
Total		20		

While the instruments used in this study were specifically adapted to measure variables related to online mathematics learning, many of the items within these instruments have broader applicability to other subjects as well. For example, the items assessing parental involvement, such as Perceived Parental Control and Perceived Parental Support, are applicable not only to mathematics but also to learning in other academic subjects, as they reflect general parental behaviors that support children's learning across disciplines. Similarly, the self-regulation instrument, while contextualized for online mathematics, measures core cognitive and metacognitive processes that are central to successful learning across subjects, such as feedback seeking, monitoring, and self-reflection. Thus, while the instruments were adapted for the specific context of online mathematics learning, their underlying constructs remain applicable to other areas of study, thus demonstrating the versatility of these instruments in assessing learning-related behaviors across different academic domains. In contrast, the parental beliefs instrument (instrumental and relational dimensions) is mathematics-specific and was not intended generalization to other academic domains. This distinction should be considered when interpretating findings.

For the preliminary analysis, given that the student self-regulation scale was adapted for a different cultural context (that is, Indonesian elementary school students) and online learning, and that previous study suggests that factor structures may vary across contexts (Yan, 2018), an exploratory factor analysis (EFA) using Jeffreys's Amazing Statistics Program (JASP) was conducted to examine the underlying dimensional structure of this instrument. The EFA was applied by using principal axis factoring (PAF) with promax rotation, as the factors were expected to be correlated (Costello & Osborne, 2011). In contrast, for the parental involvement and parental belief scale, which are adapted from previously established scales with well-defined theoretical structures (Purnomo, 2017; Silinskas & Kikas, 2019), confirmatory factor analysis (CFA) using JASP was conducted in order to examine the construct validity of each adapted instrument. We used Unweighted Least Squares (ULS) estimation with robust standard errors because of the ordinal nature of the data and the relatively small sample size (N = 125). For small to medium sample sizes, ULS is preferred over DWLS because it has been demonstrated to function well with small samples in ordinal CFA contexts (Forero et al., 2009; Savalei & Rhemtulla, 2013). The acceptance criteria for CFA were evaluated by using multiple indices: the Comparative Fit Index ($CFI \geq 0.90$), the Tucker Lewis Index ($TLI \geq 0.90$), the Root Mean Square Error of Approximation ($RMSEA \leq 0.08$), and Standard Root Mean Square Residual ($SRMR \leq 0.08$) (Hair et al., 2019; Purnomo, 2017). Items with factor loadings below 0.40 were considered for removal, and modification indices were evaluated to identify potential sources of misfit.

Descriptive analysis items (mean, standard deviation, minimum, and maximum) were calculated for all main variables, dimensions, and covariates using JASP. Mediation analysis was conducted by using JASP with the objective to examine whether parental involvement mediated the relationship between parental beliefs and students' self-regulation. An indirect effect was considered significant if the confidence interval did not include zero (Preacher & Hayes, 2008). Moderation analysis was subsequently performed to examine whether parental beliefs moderated the relationships between parental involvement and self-regulation. Finally, covariate analysis was conducted to examine whether gender, age, and grade level influenced the structural relationships among the three main variables. All statistical analyses were conducted while using a two-tailed significance criterion of 0.05.

Findings

Preliminary Studies

The preliminary analysis examined the psychometric properties of adapted scales. For the student self-regulation scale, EFA with principal axis factoring and promax rotation revealed a two-factor structure instead of the original four-factor solution. Items from the original SEFM, SEFI, and SIF dimensions were combined into the first factor, labeled Feedback Seeking Behavior (FSB), which included 11 items, with SEFM3 and SIF13 items removed. The second factor, self-reflection (SR2), consisted of the original self-reflection items (7 items). Both factors demonstrated good internal consistency (FSB: α = 0.821, SR2: α = 0.821).

For the two-factor structure of the parental involvement scale, the CFA results when using ULS estimation showed excellent model fit: CFI = 0.998, TLI = 0.997, RMSEA = 0.026 (90% CI [0.000, 0.085], p = 0.683), and SRMR = 0.068. Every factor loading, which ranged from 0.58 to 0.89, was statistically significant ($p<0.001$). Similarly, analysis of the two-factor structure of the parental belief scale yielded excellent model fit: CFI = 0.988, TLI = 0.984, RMSEA = 0.050 (90% CI [0.000, 0.082], p = 0.481), and SRMR = 0.077. Every factor loading, which ranged from 0.456 to 0.855, was statistically significant ($p<0.001$). Both scales maintained their original items, 8 for PI and 11 for PB. All constructs demonstrated good internal consistency (see Table 5).

Descriptive Data

Prior to hypothesis testing, descriptive analysis was conducted in order to describe the distribution of data for each main variable. The summary in Table 5 presents the mean, standard deviation, minimum, and maximum for all research constructs, while the covariates controlled in the further analysis were only gender, class, and age.

Table 5. *Descriptive Data Analysis Results*

	Mean	SD	Min	Max	α
Parental Involvement (PI)	3.119	0.533	1.000	4.000	0.830
Control	2.976	0.639	1.000	4.000	0.738
Support	3.258	0.563	1.000	4.000	0.787
Parental Beliefs (PB)	4.728	0.678	1.300	6.000	0.861
Instrumental	4.542	0.867	1.600	6.000	0.771
Relational	4.914	0.699	1.000	6.000	0.869
Self-Regulation (SR)	3.993	0.478	1.680	5.000	0.837
FSB	4.824	0.638	2.360	6.000	0.821
SR2	3.162	0.545	1.000	4.000	0.821
Gender (Male = 1, Female = 2)	-	-	-	-	-
Age (years)	10.22	0.906	9	12	-
Grade Level	4.94	0.826	4	6	-

Based on Table 5, the mean score for Parental Involvement (PI) was 3.119 (SD = 0.533), Parental Beliefs (PB) was 4.728 (SD = 0.678), and Student Self-Regulation was 3.993 (SD = 0.478). These findings indicate that the participants' perceptions of parental involvement and beliefs, as well as student self-regulation, tend to be at a moderate to high level with relatively low response variation, particularly in self-regulation.

Mediation Analysis

In order to answer the second research question (RQ2), the researchers conducted a mediation analysis using data that had passed the construct validity test. A mediation analysis was conducted with Parental Involvement (PI) as the mediator, Parental Belief (PB) as the predictor, and Student Self-Regulation (SR) as the outcome. The results of the mediation analysis are presented in Table 6.

Table 6. *Mediation model: Direct, Total, and Indirect Effects of Parental Beliefs on Self-Regulation*

Path	*β*	SE	*z-value*	*p*	95% CI (Lower, Upper)
PB → PI (*a*)	0.081	0.089	0.910	0.363	[-0.093, 0.255]
PI → SR (*b*)	0.765	0.037	20.414	<0.001	[0.692, 0.838]
PB → SR (*c′*)	-0.015	0.058	-0.265	0.791	[-0.129, 0.098]
PB → PI → SR	0.062	0.068	0.907	0.364	[-0.072, 0.196]
Total effect	0.047	0.089	0.552	0.602	[-0.128, 0.221]

Note. Estimator = Maximum Likelihood. *a* = PB → PI; *b* = PI → SR; *c′* = direct effect of PB on SR controlling for PI. CI = Confidence Interval.

As shown in Table 6, the path analysis revealed that PB did not significantly predict the proposed mediator, PI ($p = 0.363$). However, PI was a strong and significant predictor of SR ($\beta = 0.765$, $p<0.001$). Crucially, the indirect effect of PB on SR through PI was not statistically significant, as the 95% confidence interval [-0.072, 0.196] included zero. These results indicate that PI does not mediate the relationship between PB and SR.

Further analysis was conducted by testing mediation of all dimensions from each construct. A summary of the most critical direct path coefficients and indirect effect is presented in Table 7.

Table 7. *Mediation model: Direct, Total, and Indirect Effects Among Subdimensions*

Path / Relationship	*β*	SE	z-value	*p*	95% CI [Lower, Upper]
Significant Direct Effects					
Instrumental → Support	0.209	0.099	2.110	0.035*	[0.015, 0.404]
Relational → FSB	-0.210	0.095	-2.225	0.026*	[-0.396, -0.025]
Control → SR2	0.471	0.026	18.348	<0.001***	[0.412, 0.522]
Support → SR2	0.645	0.026	25.220	<0.001***	[0.594, 0.695]
Significant Indirect (Mediation) Effect					
Instrumental → Support → SR2	0.135	0.065	2.077	0.038*	[0.008, 0.262]
Significant Total Effect					
Instrumental → FSB	0.211	0.098	2.142	0.032*	[0.018, 0.404]
Relational → FSB	-0.226	0.098	-2.296	0.022*	[-0.418, -0.033]

Note. Estimator = Maximum Likelihood. CI = Confidence Interval. *p<0.05. ***p<0.001.

Based on Table 7, the analysis of direct pathways revealed that instrumental beliefs had a significant positive direct impact on parental support ($\beta = 0.209$, $p = 0.035$). Conversely, relational beliefs demonstrated a significant negative direct effect on FSB ($\beta = -0.210$, $p = 0.026$). Notably, both control and support were strong positive predictors of SR2 ($\beta = 0.471$ and $\beta = 0.645$, respectively, both $p<0.001$). No other direct paths reached statistical significance levels (all $p > 0.05$). In Table 7, among the eight tested indirect pathways, only one was statistically significant, specifically, the indirect effect of instrumental beliefs on self-reflection through parental support ($\beta = 0.135$, $p = 0.038$, 95% CI [0.008, 0.262]). This indicates that instrumental beliefs are associated with higher self-reflection because they increase parental support, which, in turn, enhances self-reflection. No other indirect effect was significant. Table 7 also shows that instrumental beliefs had a significant positive total effect on FSB, while relational beliefs had a significant negative total effect on FSB.

Moderation Analysis

To answer the third research question (RQ3), moderation analysis was conducted by using the validated constructs. This analysis examined whether Parental Belief moderated the relationship between Parental Involvement and Student Self-regulation. The results of the moderation analysis are presented in Table 8.

Table 8. *Moderation output (SR2 output)*

Model	*b*	SE	*t*	*p*
Intercept	1.017	1.215	0.837	0.404
PB	0.180	0.259	0.696	0.488
PI	0.994	0.416	2.390	0.018
PB × PI	-0.066	0.088	-0.747	0.456

Note. Dependent variable: Student self-regulation.

As shown in Table 8, the interaction term between PB and PI had a coefficient value of -0.066 and was not statistically significant ($p = 0.456 > 0.05$). These results indicated that Parental Belief did not significantly moderate the relationship between Parental Involvement and Student Self-regulation.

Covariate Analysis

To answer the fourth research question (RQ4), the effects of covariate variables (gender, age, and grade level) on Parental Involvement, Parental Belief, and Student Self-regulation were examined by using ANCOVA. The results are presented in Table 9.

Table 9 shows that, among the tested covariates, only gender had a significant effect on Parental Belief ($t = 2.210$, $p = 0.029$). This result indicated that students' perceptions of parental beliefs differed significantly based on gender. In contrast, age and grade level did not significantly influence Parental Belief. Furthermore, none of the covariate variables significantly affected Student Self-regulation or Parental Involvement, as all corresponding significance values were greater than 0.05. These findings suggest that demographic characteristics played a limited role in shaping the structural relationships among the parent-related variables (PI and PB) and the student-related variable (SR).

Table 9. *ANCOVA Test Results*

Dependent Variable	Parameter	Std. Error	*t*	*Sig.*	*Partial η²*
Parental Belief	Intercept	0.824	4.650	0.000	0.152
	Age	0.127	1.083	0.281	0.010
	Grade	0.140	-1.064	0.290	0.009
	Gender	0.123	**2.210**	**0.029**	**0.039**
Student Self-regulation	Intercept	0.739	5.368	0.000	0.191
	Age	0.114	0.730	0.467	0.004
	Grade	0.126	-0.632	0.529	0.003
	Gender	0.111	1.593	0.114	0.020
Parental Involvement	Intercept	0.650	5.690	0.000	0.210
	Age	0.100	-1.125	0.263	0.010
	Grade	0.111	0.878	0.382	0.006
	Gender	0.097	0.616	0.539	0.003

Note. Significant effects ($p<0.05$) are highlighted in bold.

Discussion

This study examined the complex relationships among parental beliefs, parental involvement, and student self-regulation in online mathematics learning. The findings reveal several important patterns that contribute to the literature on parental engagement in online learning settings.

The Structure of Student Self-Regulation in Online Mathematics Learning

A key finding of the study revealed a two-factor structure for student self-regulation, contrasting with the original four-factor model by Yan (2018). The first factor identified, i.e., Feedback Seeking Behavior (FSB), integrates elements from the Seeking External Feedback Monitoring (SEFM), Seeking External Feedback Inquiry (SEFI), and Seeking Internal Feedback (SIF) dimensions. The second factor, Self-Reflection (SR2), remained separate, while focusing on students' reflective thinking regarding their learning processes.

This structural change can be attributed to several factors related to the developmental stage of the participants aged 9–12, who may not distinguish between different self-regulatory behaviors, leading to a unified approach in engaging with feedback from multiple sources (Zimmerman, 2002). The online learning environment further complicates these behaviors as it requires simultaneous comprehension monitoring and clarification-seeking through online means. Cultural differences, particularly among Indonesian students, may also redefine self-regulated learning compared to Western models. Despite these influences, the retention of self-reflection as a distinct factor highlights its role as a higher-order metacognitive process, thus suggesting that it remains a vital, separate component of self-regulation in educational practices.

The Direct Effect of Parental Involvement on Student Self-Regulation

A robust finding was the significant positive direct effect of parental involvement on self-regulation. Both control and support strongly predicted self-reflection, underscoring the critical role of parents in shaping regulatory capacity in online mathematics contexts. These findings align with research documenting the importance of family involvement for academic outcomes (Boonk et al., 2018; Wilder, 2014). In mathematics, parental involvement enhances student engagement, motivation, persistence, and strategic problem-solving (Purnomo et al., 2024; Silinskas & Kikas, 2019; Wu et al., 2022). Our findings extend this to online learning, demonstrating that parents remain influential even when instruction occurs remotely.

The research indicates that parental support extends to online learning, emphasizing the importance of emotional encouragement and constructive assistance in developing students' metacognitive skills. When parents ask guiding questions, encourage explanation of thinking, and help children learn from mistakes, they model reflective processes that students internalize (Grolnick & Pomerantz, 2022). The significant effect of control also merits attention. While controlling involvement is sometimes associated with negative outcomes in Western contexts (Pomerantz et al., 2007), our findings suggest that, in the Indonesian context, parental monitoring may serve a protective function, particularly in online learning where teacher supervision is reduced. In collectivist cultures emphasizing filial piety, parental control may be perceived as care and provide a necessary structure that supports autonomy development (Chao, 1994).

The Mediating Role of Parental Support

The mediation analysis revealed that parental support fully mediated the relationship between instrumental beliefs and self-reflection. Instrumental beliefs, which focus on procedural accuracy, quick problem-solving, and mastery of mathematical rules, were positively associated with parental support, which, in turn, enhanced students' self-reflective capacity. This full mediation effect indicates that instrumental beliefs alone do not directly promote self-reflection; rather, these beliefs must be expressed through supportive parental actions so that to impact self-reflection positively.

This finding aligns with Drummond and Stipek's (2004) emphasis that supporting behaviors are necessary for positive beliefs to promote autonomy. In mathematics, where self-reflection involves analyzing strategies, evaluating understanding, and learning from errors (Ferreira et al., 2022), support that includes guiding questions and constructive feedback may be particularly beneficial. Parents with strong instrumental beliefs may be more likely to provide structured, task-focused support which facilitates the development of reflective skill.

At the construct level, parental involvement did not mediate the relationship between parental beliefs and self-regulation, thus indicating that strong beliefs do not necessarily lead to perceived involvement due to practical constraints, work demands, and limited technological skills that limit actual involvement (Hornby & Lafaele, 2011). While general beliefs did not predict involvement, instrumental beliefs predicted parental support. This suggests that relationships may exist at a dimensional level even if they are non-significant at the construct level. Notably, instrumental beliefs enhance self-reflection through supportive practices, and not control, which aligns with self-determination theory (Ryan & Deci, 2000). Additionally, in online settings, obtaining feedback often depends more on one's technological aptitude+ than on parental involvement (Pelikan et al., 2021). The finding highlights that the absence of construct-level mediation does not imply a lack of relevant connections; rather, these connections are nuanced and specific, emphasizing the need for multidimensional approaches in family-school research.

The Differential Role of Relational Beliefs

An unexpected finding showed a negative direct effect of relational beliefs on feedback seeking behavior (FSB), where stronger relational beliefs predicted less active feedback seeking. Possible interpretations include that parents with strong relational beliefs foster confidence in their children's internal reasoning, thus reducing the perceived need for external consultation, which aligns with self-determination theory (Ryan & Deci, 2000), where autonomy support can foster self-directed learning. Alternatively, high parental expectations may discourage children from disclosing knowledge gaps, or else, students may prefer to solve problems independently rather than engaging in asynchronous communication (Pelikan et al., 2021).

The Non-Significant Moderation Effect

Parental beliefs do not influence the connection between involvement and self-regulation, indicating that this relationship remains consistent regardless of belief levels. The development of self-regulation is complex, as it involves interactions among students, instructional settings, and wider social contexts (Wong et al., 2019). In mathematics, the key factors such as classroom support, guided practice, and peer discussions are crucial for enhancing regulatory skills (Bakker et al., 2015), suggesting that varying influences can overshadow the impact of any one parental trait.

The Role of Demographic Covariates

Gender had a near-significant effect on parental beliefs, with females reporting slightly higher parental beliefs. This aligns with research suggesting gender differences in perceptions of parental academic expectations (Bubić et al., 2020). Females may be more attuned to parental expectations and engage in more frequent academic conversations (Parmar & Nathans, 2022). In the Indonesian context, where mothers are primary educational caregivers for daughters (Purnomo et al., 2022), this relationship may enhance females' awareness of parental beliefs. Additionally, no significant age or grade effects were observed, which suggests that demographic variation within upper elementary grades did not systematically impact parental beliefs, parental involvement, or student self-regulation. This finding is consistent with Osorio-Saez et al. (2021), who noted that, in online learning contexts, technological demands shape parental roles more strongly than demographic characteristics.

Limitations and Future Research Directions

While this study provides valuable insights, several limitations should be acknowledged nevertheless. Firstly, the cross-sectional design restricts causal inference, as it captures data at a single time point, thus failing to reflect developmental patterns and bidirectional relationships between students' self-regulation skills and parental involvement. Future research is recommended to use longitudinal designs in order to better understand how these dynamics evolve, particularly during transitions between grade levels and shifts in online learning environments. Secondly, the reliance on self-report measures introduces potential bias, as student perceptions may fail to accurately reflect parental behaviors. High mean scores on self-regulation measures indicate possible ceiling effects or social desirability bias. It is suggested that future studies should incorporate data from multiple informants (e.g., parents, teachers) and methods (e.g., observations, experience sampling, digital trace data), for a more comprehensive understanding of family-school interactions in online learning contexts. Thirdly, the relatively small sample size (N=125) could limit the statistical power in detecting smaller effects, particularly in moderation analyses. Although appropriate statistical methods were used, larger sample sizes are encouraged for better robustness in testing complex relationships. Fourthly, changes in the self-regulation instrument indicate that comparisons to previous studies with a four-factor structure should be approached cautiously, as the merging of factors may represent a broader construct with different implications. Future research should investigate the replicability of this structure across different samples and its predictive validity regarding academic outcomes. Lastly, the study's focus solely on mathematics raises questions about the generalizability of findings to other subjects, given the unique characteristics of mathematics as a subject. Future comparative studies could clarify whether the observed patterns of parental involvement and self-regulation generalize across academic domains. Despite these limitations, the study offers valuable insights into the interplay of parental beliefs and involvement in fostering students' self-regulated learning in online mathematics contexts, highlighting pathways for potential interventions.

Conclusion

This study examined the relationships among parental beliefs, parental involvement, and student self-regulation in the context of online mathematics learning for upper elementary students. The findings revealed several important patterns that advance our understanding of family influences on self-regulated learning in digital environments. First, the student self-regulation instrument indicated a two-factor structure, delineating feedback-seeking behavior and self-reflection, reflecting developmental stages and online learning contexts. Second, mediation analysis showed that parental support fully mediated the link between instrumental beliefs in mathematics and self-reflection, thus highlighting specific pathways for enhancing the students' reflective capabilities. Third, relational beliefs negatively impacted feedback seeking behavior, suggesting potential discouragement of help-seeking from parents focused on conceptual understanding. Fourth, parental beliefs did not significantly moderate the involvement-self-regulation relationship, which suggests that involvement influences self-regulation similarly across different belief orientations. Fifth, a near-significant gender difference was noted, with females perceiving higher parental beliefs than males, although age and grade had no effect. These findings have implications for improving parental involvement in online mathematics learning and suggest further research using longitudinal and cross-cultural methods so that to better understand family support in digital education environments.

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Conflict of Interest

All authors declare that there is no conflict of interest associated with the publication of this article.

Author contributions

Yoppy Wahyu Purnomo: conceptualization, visualization, writing – review and editing, formal analysis.
Pasri: investigation, data curation, formal analysis.
Mohammad Archi Maulyda: writing – original draft, formal analysis.
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Azza Ilvana Mas'ud: writing – original draft.

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