The Role of Self-Regulation in the Relationship Between Adaptability and Engagement: A Case of Online Mathematics Learning for Elementary School Students

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Abstract

The dynamics of students' engagement in online mathematics learning during the pandemic have differed significantly from face-to-face learning. To further investigate this, the current study aims to examine the relationship between student adaptability and engagement, taking into account the mediating role of self-regulation and the influence of grade level, parental education level, student age, and student gender. A total of 339 students, with an average age of 11.16 years, from three public elementary schools in Yogyakarta, Indonesia, participated in this study. The findings of the study revealed the following: 1) adaptability significantly and positively predicts students' self-regulation, 2) in turn, self-regulation significantly and positively predicts student engagement in online mathematics learning, and 3) adaptability has a significant positive impact on student engagement, both directly and through the mediation of student self-regulation. These findings have significant implications for the student learning environment, particularly with regard to parental involvement. Recommendations are provided for creating environmental conditions that promote online learning engagement through adaptability and self-regulation.

Keywords: Adaptability, elementary school, online mathematic learning, self-regulation, student engagement

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Finding ways to preserve the benefits of in-person classroom instruction is a major challenge in online education. Sustaining students' attention and engagement during online lessons requires incorporating gestures, ensuring visibility to students as they interact with the material, and effectively conveying non-verbal social cues such as body language and eye contact (Fiorella et al., 2018; Stull et al., 2018). These factors are especially critical when teaching abstract concepts or utilizing mathematical notions to facilitate effective student learning.

Research has consistently shown that student engagement plays a central role in academic achievement and overall academic well-being across various subjects (Fung et al., 2018; Zhang et al., 2021). However, the shift to remote learning has presented students with new challenges, compelling them to adapt and adjust rapidly in order to avoid falling behind. In this study, we specifically focused on students' adaptation and self-regulation in response to change, particularly during the COVID-19 pandemic, and examined how these factors were related to student engagement in online mathematics learning.

The multidimensional nature of school engagement is widely recognized. In particular, there is general agreement with the conceptualization of engagement proposed by Fredricks et al. (2004), which encompasses affective, cognitive, and behavioral elements. Affective involvement refers to a sense of belonging to the school, feelings of acceptance from teachers and peers, and perceiving the school as a supportive environment. “Behavioral engagement includes actions such as attendance and participation in school activities,” while “cognitive engagement” is defined as “the willingness to engage in challenging tasks, goal-directedness, strategic use, and self-regulation” (Sinatra et al., 2015, p.2). In today's context, engagement may also encompass the environment (Shernoff & Bempechat, 2014) and technology (Schindler et al., 2017) as relevant factors.

The learning environment is seen to be very influential and flexible in terms of engagement. Online learners complete their coursework in one or more behavioral settings that aren't always intended as learning environments. The physical environment can impact students' learning and performance through cognitive factors, such as attention disturbance and decreased concentration, physiological factors, such as changes in temperature and comfort level; and affective factors, for example, motivation. This is supported by the revised edition of the cognitive load model (Choi et al., 2014). Students in online programs have highlighted the need for a practical and comfortable environment with adjustable lighting, noise levels, temperature, movement and ergonomic furniture (Alphonse et al., 2019; Beckers et al., 2016). Online teachers and students require access to a variety of computer equipment, high-speed Internet, wireless connections, and power outlets (Beckers et al., 2016). Additionally, parents play a significant role in directing and supervising their children's at-home teaching and learning activities in accordance with the teacher's instructions. According to Alia and Irwansyah (2018), parents play a crucial part in helping kids use technology. Parents who struggle with technology and are unable to operate it can inadvertently add pressure on their children, as they are unable to assist them in using technology (Purnomo et al., 2022).

For the majority of students, online learning became the new norm during the COVID-19 pandemic that struck the world in the years 2020–2022. Online learning, which entails interaction between students and teachers via remote access to the Internet (Casimiro, 2016), requires swift adaptation from both instructors and students. This, in turn, contributed to issues regarding student engagement, including a lack of supporting infrastructure, negative student-teacher attitudes toward online learning, boredom, failed classes, and psychological stress (Ferri et al., 2020; Irfan et al., 2020; Purnomo et al., 2021; Xu & Xu, 2019).

The lack of face-to-face connection in online learning can cause students to feel isolated and separated from their learning community since communicating and sharing information with classmates and instructors becomes challenging (Friesen & Kuskis, 2013; Xu & Jaggars, 2014).

According to Irfan et al. (2020), online teaching presents challenges, particularly in math education, due to limitations in representing mathematical symbols and the functional capacity of the learning management system to facilitate communication during math lessons. Mathematical concepts are often complex and abstract, and teachers typically rely on various tools such as charts, whiteboards, and manipulatives to convey these concepts. The exchange of information and communication patterns with students in online settings requires teachers to adapt and switch between different modes.

Drawing from the theory of embodied cognition, learning is viewed as involving not only the mind but also the entire body. Researchers have also identified three types of gestures that embody mathematical knowledge: pointing, symbolic, and metaphorical. These gestures can enhance students' visual perception (Alibali & Nathan, 2012) and aid in their understanding of abstract concepts. Therefore, learning mathematics online requires a unique set of soft skills, which we identify as adaptability and self-regulation in this study.

Adaptability refers to how students respond and adjust to new situations (Collie et al., 2017; Collie & Martin, 2017; Holliman et al., 2018). In the context of online mathematics learning, adaptability becomes particularly crucial due to its unique challenges and demands. Mathematics encompasses a broader scope beyond counting, memorization, and formula application, involving human activity (Pramudiani et al., 2016), context (Pramudiani et al., 2017), and social connectedness (Yoppy Wahyu Purnomo et al., 2016). Therefore, online mathematics learning poses significant challenges.

Engaging in online mathematics learning requires students to navigate the digital environment, interact with online resources, and engage in virtual communication and collaboration. This dynamic context necessitates adaptability as students must adjust their ideas, attitudes, and behaviors to effectively learn and engage in online mathematics activities. Students who demonstrate adaptability are more likely to possess the self-regulatory skills necessary for effective online mathematics learning. They can set clear objectives, control their behaviors, and make necessary adjustments to their learning process (Zimmerman, 2000). Adaptability enables students to cope with uncertainties, embrace new technologies, and explore alternative approaches. Their ability to adjust and regulate their learning process in the online environment sets them up for success in their mathematical pursuits. Previous research by Collie and Martin, (2017) has shown that student-reported adaptability predicts students' mathematical engagement, indicating the importance of adaptability for present and future learning.

While previous studies have examined adaptability and student engagement in the context of online learning (Besser, Flett, & Zeigler-Hill, 2020; Besser, Flett, Nepon, et al., 2020; Dumford & Miller, 2018; Gopakumar, 2020; Lee et al., 2023; Zhang et al., 2021), the role of self-regulation in the relationship between adaptability and student engagement, particularly in online mathematics learning for elementary school students, remains unexplored.

This study aims to investigate the role of self-regulation in the relationship between adaptability and engagement in the context of elementary school students and online mathematics learning. To meet the research aims, the following research questions were asked:

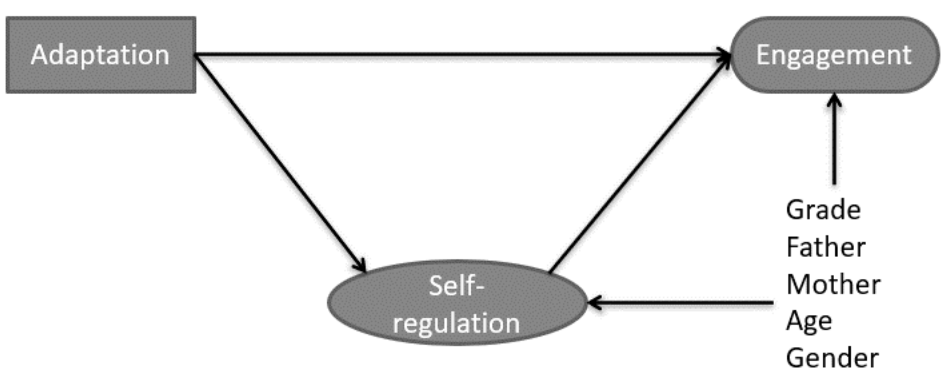
1. How does adaptability predict self-regulation?
2. How does self-regulation predict student engagement?
3. How does adaptability predict student engagement, either directly or through the mediation of self-regulation?

Additionally, we aim to examine how covariate factors such as grade level, parental education level, student age, and student gender predict student engagement and self-regulation.

Figure 1 depicts a graphic mediation model that depicts these study concerns. In addition, this paper also presents psychometric evidence of the measurement scale.

Figure 1

Mediation Model of Self-Regulation in Terms of the Relationship Between Adaptability and Student Engagement



Studies on student self-regulation and engagement have examined various demographic factors, including gender, age, class, and parental education, which are believed to influence students' abilities to regulate their own learning and engage in educational activities. For example, Liu et al. (2021) dan Zhao et al. (2014) have explored gender and its relationship with student self-regulation, while (Holliman et al., 2018) and (Wang et al., 2016) have examined the connection between gender and student engagement. These studies have investigated how gender influences students' self-regulatory skills and their level of engagement in educational activities.

Age has also been a demographic factor of interest in relation to student self-regulation and engagement. Zhao et al. (2014) and Holliman et al. (2018) have examined the association between age and these variables, exploring how students' developmental stage may affect their ability to self-regulate and engage in learning activities.

Grade level has been considered another demographic variable concerning student self-regulation and engagement. Gomes et al. (2019), Zhao et al., (2014), and Wang et al. (2016) have studied the impact of grade level on these factors, investigating how students' educational experiences and classroom environments contribute to their self-regulatory abilities and level of engagement. In addition to the aforementioned demographic factors, parents' educational level has gained attention in relation to student engagement in online learning. (Purnomo, et al., 2022) emphasized that highly educated parents, regardless of their socio-economic status, are thought to possess more knowledge and resources to support their children's learning, including promoting self-regulation and effectively leveraging technology.

It is important to acknowledge that these demographic factors may vary across different cultural, social, and educational contexts, leading to inconsistent findings in the literature. Nevertheless, studying these factors in greater depth can provide valuable insights into the specific characteristics that influence student self-regulation and engagement in learning.

Theoretical Underpinning

Adaptability

The ability to adapt to a new and unexpected academic environment is referred to as adaptability in the context of learning and schooling. Our viewpoint aligns with Collie and colleagues (Collie et al., 2017; Collie & Martin, 2017; Holliman et al., 2018), who define adaptability as the capacity to adjust to new situations. They describe adaptability as the modification and regulation of cognitive, behavioral, and emotional functions in an uncertain and constantly changing environment, condition, or situation.

Adaptability is often associated with theories of resilience, coping ability, and buoyancy (Martin et al., 2012, 2013). However, adaptability differs from resilience, coping, and buoyancy as it focuses on managing change and uncertainty, among other factors, rather than specifically dealing with difficult or stressful situations.

In addition, Martin et al. (2012) developed a scale with four components to assess adaptability: (a) responses to newness, change, variability, or uncertainty; (b) cognitive, behavioral, or affective functions; (c) regulation, adjustment, improvement, or new forms of accessing the three functions; and (d) constructive goals or outcomes. The analysis resulted in the identification of two factors: cognitive-behavioral and affective factors. These factors slightly differ from those proposed previously. We utilized this scale to measure student adaptability.

Self-Regulation in Online Mathematics Learning

Referring to the empirical test conducted by Martin et al. (2013), adaptability and self-regulation are differentiated in their study, exploring their individual contributions to academic and non-academic outcomes. Self-regulation models typically encompass a broad focus on managing and directing one's thoughts and behaviors in various learning contexts and in response to academic demands. In contrast, adaptability narrows its focus to the specific ability to navigate and cope with uncertainty, novelty, and challenging situations.

According to Zimmerman (2000), self-regulation is not merely a mental capacity or skill for academic success; rather, it is a self-directed process through which learners translate their mental abilities into academic skills. Learning is seen as a proactive activity in which students engage, rather than a passive occurrence resulting solely from instruction. Self-regulation involves generating, monitoring, organizing, and controlling one's ideas, attitudes, and actions aimed at achieving goals (Pintrich, 2000; Zimmerman, 2000).

In terms of measurement, Koivuniemi et al. (2021) mention that self-regulated learning (SRL) is commonly assessed using questionnaires and self-reports, with the Motivated Strategies for Learning Questionnaire (MSLQ) being the most frequently used instrument. However, the MSLQ was originally designed for college students and may not be suitable for elementary school students due to the number of items. Therefore, we employ the Self-Regulation Questionnaire-Academic (SRQ-A), developed by Ryan & Connel (1989). Additionally, Gomes et al. (2019) state that the SRQ-A is specifically designed for elementary and secondary school students. The SRQ-A assesses the extent to which an individual's motivation for a specific behavior is relatively autonomous or controlled, based on the reasons provided by students for their engagement in school-related activities. The SRQ-A consists of four subscales that reflect the continuum of Self-Determination Theory, ranging from extrinsic motivation to intrinsically motivated behavior, along with four corresponding regulatory styles: three types of extrinsic motivation (external, introjected regulation, and identified regulation) and intrinsic motivation (intrinsic regulation). Gomes et al. (2019) evaluated this questionnaire in the context of primary school students in Portugal for the study. They produced a valid and dependable instrument. We used the same questionnaire but translated it into Indonesian.

Student Engagement in Online Mathematics Learning

For decades, students' engagement in learning has been studied and demanded in the literature (Ferrer et al., 2020; Fredricks et al., 2011). According to Fredricks and colleagues (Fredricks & McColskey., 2011; Fredricks et al., 2004), the concept of student engagement includes at least three constructs: behavioral engagement, emotional engagement, and cognitive engagement.

Behavioural engagement refers to students' participation in academic, social, or extracurricular activities both at and outside school (Fredricks et al., 2004). Research by Fung et al. (2018) suggests that students who actively participate and are organized in class are more likely to overcome learning difficulties. For example, students who dedicate effort to completing math homework and engage in discussions with their peers about math problems demonstrate better preparation for success in school.

Emotional engagement focuses on students' positive or negative reactions to teachers, classmates, lessons, and the overall school environment. Positive emotional engagement fosters a sense of connection between students and the school, influencing their motivation to learn. In the case of mathematics, which is sometimes perceived as less interesting and can provoke anxiety among students, affective engagement becomes crucial for successful mathematics learning (Radišić et al., 2015).

Lastly, cognitive engagement pertains to students' persistence and the use of cognitive strategies during the learning process. This includes not giving up when faced with challenges and going beyond what is expected to solve math problems. Furthermore, cognitive engagement involves employing effective strategies to handle and process large amounts of information while solving mathematical problems (Fredricks et al., 2004). So, in this study, we combined the three types of engagement to measure mathematical engagement constructs commonly used in the literature comprehensively. We also include an online component in mathematics learning that is relevant to current situations and conditions.

Method

Participants

The participants of this study were 339 students from three public primary schools in Yogyakarta Special Region, Indonesia. Participants were selected using convenience sampling. They consist of students in the upper grades 4, 5, and 6 with an average age of 11,16 years (SD = 0.99). All respondents provided informed consent to participate in the study/processing of their replies. Details of participants can be seen in Table 1.

Table 1

Student Participant Profile

Based on		Sub-sum	%
Class	IV	120	35.4
	V	112	33.0
	VI	107	31.6
Gender	Male	156	46
	Female	183	54
Age	7 years	1	0.3
	9 years	1	0.3
	10 years	90	26.5
	11 years	123	36.3
	12 years	104	30.7
	13 years	16	4.7
	14 years	2	0.6
	16 years	2	0.6
Mother's last education	Elementary school	26	7.7
	Junior high school	63	18.6
	Senior high school	194	57.2
	Higher education	52	15.3
	No description	4	1.2
Father's last education	Elementary school	40	11.8
	Junior high school	61	18.0
	Senior high school	194	57.2
	Higher education	44	13.0

As Table 1 shows, our sample is fairly balanced across gender: 46% for male and 54% for female. The last education of their mothers and fathers tends to be dominated by high school level and equal.

Instruments and Data Collection

Online questionnaires were utilized as a means to collect data. Researchers sought assistance from teachers to distribute the questionnaires by sharing links with their students through various communication channels, including WhatsApp groups, email, or instant messages. This collaborative approach proved effective in reaching a larger sample size and facilitating data collection. Teachers are often valuable allies in research as they have direct access to students and can help ensure a higher response rate. A consent form, instructions, and brief information on the research accompanied the link.

This online questionnaire is divided into two parts. The first part deals with demographic questions such as name, age, school origin, grade, father's last education, and mother's last education. The second part is the core part of the measured three scales: adaptability, independence, and student engagement in online mathematics learning. Each of these scales is explained separately in the following points.

Student Adaptability

This study measured adaptability using a five-point Likert scale adapted from Martin et al. (2012). This scale has two components: six for cognitive-behavioral adaptability and three items for affective adaptability. Martin et al. (2012) used this scale to assess middle and high school students. As a result, the statement items on this were adapted to the context of elementary school students' levels and mathematics classes in Bahasa Indonesia following back translation method. For example, the original statement, "I am able to think through a number of possible options to assist me in a new situation" was translated as "I can think of a number of possible options to help me in a new situation."

Student Self-Regulation in Online Mathematics Learning

The self-regulation instrument of this study was adapted from Gomes et al. (2019). This study involved 341 Portuguese elementary school children ranging from 8 to 11 years old from the third and fourth grades. This study produced 16 out of 24 items that were developed and included in four factors: external, introjected, identified, and intrinsic. The items are rated along a 5-point response scale ranging from 1 (never) to 5 (always). The reliability of each of these factors is 0.80, 0.76, 0.79, and 0.82, respectively.

Student Engagement in Online Mathematics Learning

The student engagement instrument used in this study was an adaptation of the Rimm-Kaufman and colleagues' instrument (Leis et al., 2015; Rimm-Kaufman et al., 2015). Rimm-Kaufman and colleagues used this scale with 387 grade 5 students in one suburban district in the mid-Atlantic states. The scale assesses engagement on three aspects: social, cognitive, and emotional. Thirteen of the 15 items compiled met the validity and reliability criteria, including five items of emotional engagement ($\alpha = 0.91$), four items of social engagement ($\alpha = 0.98$), and four items of cognitive engagement ($\alpha = 0.89$).

We adapted the instrument to be used for online mathematics learning. All statements included the phrase "in online mathematics learning." Some phrases were added at the beginning of the sentence and some at the end. For example, the original item was "Students in my math class helped each other to learn today." But after the translation, the item read as "Friends help each other in online learning math."

Data Analysis

Descriptive statistical analysis, such as the mean (M), standard deviation (SD), and the range between the average items (minimum and maximum), was used to examine the profile trends associated with each variable. We used mediation analysis using PROCESS to examine the relationship between the main and moderating variables.

The confirmatory factor analysis (CFA) procedure was conducted prior to the main analysis to assess the convergent and discriminant validity of the instruments. Internal consistency testing was performed using Cronbach's alpha, with a coefficient of 0.6 being the threshold to meet the criteria (Clark & Watson, 1995; Nunnally & Bernstein, 1994).

Results

Preliminary Analysis

Along with descriptive and correlation analysis, we conducted a confirmatory factor analysis (CFA) for each instrument to examine their construct validity. Additionally, this analysis helped assess the possibility of enhancing the scale's structure. The reliability of each factor in the scales was also assessed using Cronbach's alpha.

Adaptability

The model fit for the adaptability scale was at a good level with NC = 1.70, CFI = 0.98, RMSEA = 0.05, and SRMR = 0.04. The model retained 16 existing items. Each item has a loading factor of more than 0.5 with a minimum of 0.59 and a high of 0.816. In addition, the composite reliability for the behavior is 0.86, and the affective factor is 0.73. The Average Variance Extracted (AVE) coefficient obtained a value close to 0.5, namely 0.473 for the affective factor and 0.498 for the behavior factor. The results of the descriptive validity test using Heterotrait-Monotrait (HTMT) analysis obtained a coefficient value of 0.808. Therefore, the issues concerning discriminant validity were addressed, and based on the obtained test results for convergent validity and discriminant validity, the constructs met the criteria for both validity measures.

Self-Regulation

The CFA for the self-regulation scale was carried out using two simulations. The first simulation used the first-order factor, and the second simulation used the second-order factor. The first model obtained NC = 3.25, CFI = 0.92, SRMR = 0.06 and RMSEA = 0.08. Similar results were obtained by model 2, namely NC = 3.27, CFI = 0.92, SRMR = 0.06, and RMSEA = 0.08. We used the second model to describe the self-regulation scale. The second model contained two dimensions: intrinsic regulation and extrinsic regulation factor. For the second model, the loading factor of each item in the first factor ranged between 0.79 and 0.94, while the items in the second order factor ranged between 0.52 and 0.89. All items were included in the subsequent analysis. In addition to factor loading, several criteria were used to analyze convergent and discriminant validity and reliability.

The CR (Composite Reliability) for the two factors obtained decent coefficients: 0.86 for the extrinsic factor and 0.88 for the internal factor. The AVE coefficients for these two factors were also adequate as they were above 0.5. Specifically, the extrinsic factor had an AVE coefficient of 0.75, and the internal factor had an AVE coefficient of 0.78. Therefore, this model demonstrated very good convergent validity. The analysis of discriminant validity also yielded positive results, as indicated by the HTMT analysis. The HTMT values were below the threshold of 0.85, with a value of 0.37, indicating satisfactory discriminant validity. Reliability, assessed using Cronbach's alpha, also yielded coefficients higher than 0.7 for both factors: 0.89 for the extrinsic factor and 0.89 for the intrinsic factor.

Engagement

The three factors engagement scale showed a good fit with NC = 2.43, CFI = 0.94, RMSEA = 0.07, and SRMR = 0.07. This 3-factor model retained 13 items with a loading factor of 0.51 to 0.86. The CR coefficients for each factor were 0.76 for the cognitive-behavior factor, 0.69 for the social factor, and 0.79 for the emotional factor. The AVE values were also close to 0.5, with the cognitive-behavior factor at 0.44, the emotional factor at 0.53, and the social factor at 0.49. Based on the loading factors, CR coefficients, and AVE values, the engagement scale met the requirements for convergent validity. The discriminant validity of the scale was also adequate, as indicated by the HTMT. The HTMT values were 0.33, 0.44, and 0.78, all below the threshold of 0.85, indicating satisfactory discriminant validity.

Descriptive Data and the Relationship Between Factors

Table 2 provides descriptive statistics such as mean, SD, minimum and maximum, and skewness, kurtosis, and bivariate correlation for study variables. Based on the data in Table 2, the difference between the two factors is not too big for the adaptability variable. The cognitive-behavior factor (M = 3.42, SD = 0.85) is higher than the affective factor (M = 3.22, SD = 0.93). The highest average for factors in student engagement is obtained by cognitive factor (M = 3.15 and SD 0.45), followed by social and emotional factors. The lowest mean for the self-regulation variable was introjected (M = 2.45, SD = 1.25). This result also aligns with the mean of extrinsic factors in the second fit model of student self-regulation (M = 2.87, SD = 1.14). On the other hand, the identified factor obtained the highest mean (M = 4.06, SD = 0.88).

Each pair was positively and significantly correlated with $p < 0.001$ among the three variables. The strongest correlation was between adaptability and self-regulation ($r = 0.45$, $p < 0.001$). Each factor in adaptability, both cognitive-behavior and affective, were significantly correlated with each factor on the dimensions of self-regulation and engagement. The strongest correlation was the pair of cognitive-behavior and intrinsic ($r = 0.48$, $p < 0.01$) and followed by cognitive-behavior and identified factor ($r = 0.48$, $p < 0.01$) and cognitive-behavior and internal factor ($r = 0.41$, $p < 0.01$). The weakest correlation was shown by affective and extrinsic pairs ($r = 0.115$, $p < 0.01$). Apart from that, Table 2 also shows that all extrinsic factors in self-regulation

Table 2

Descriptive Data and Correlation Between Factors

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Ext	1	0.65**	0.26**	0.27**	0.28**	0.91**	0.02	0.03	0.08	0.25**	0.12*	0.79**	0.06	0.20**	-0.15**	0.06	-0.16**	-0.01	-0.07
2. Intro		1	0.26**	0.30**	0.30**	0.91**	0.02	0.07	0.14*	0.27**	0.15**	0.80**	0.10	0.23**	-0.09	0.05	-0.14**	-0.04	-0.12*
3. Iden			1	0.73**	0.93**	0.29**	0.35**	0.06	0.21**	0.48**	0.36**	0.68**	0.27**	0.46**	-0.07	0.18**	-0.08	0.10	-0.05
4. Int				1	0.93**	0.31**	0.34**	0.16**	0.37**	0.42**	0.37**	0.70**	0.38**	0.44**	-0.16**	0.14**	-0.19**	0.05	-0.05
5. Intrin					1	0.32**	0.37**	0.12*	0.31**	0.48**	0.39**	0.74**	0.35**	0.48**	-0.12*	0.17**	-0.14**	0.08	-0.06
6. Extern						1	0.03	0.05	0.12*	0.29**	0.15**	0.87**	0.10	0.26**	-0.13*	0.06	-0.16**	-0.02	-0.11
7. Cog							1	0.25**	0.49**	0.27**	0.24**	0.21**	0.76**	0.28**	0.03	0.29**	0.06	0.14*	0.01
8. Soc								1	0.26**	0.15**	0.14**	0.10	0.71**	0.16**	0.02	0.06	0.01	-0.06	0.01
9. Emo									1	0.22**	0.19**	0.25**	0.77**	0.22**	-0.03	0.16**	0.02	-0.01	-0.01
10. ogbeh										1	0.63**	0.45**	0.28**	0.89**	0.02	0.12*	0.07	0.08	0.06
11. ffect											1	0.31**	0.25**	0.91**	-0.04	0.11*	0.01	0.12*	0.10
12. elf												1	0.24**	0.42**	-0.16**	0.13*	-0.19**	0.03	-0.10
13. ngage													1	0.29**	0.01	0.22**	0.03	0.02	0.00
14. dapt														1	-0.01	0.13*	0.05	0.11*	0.09
15. ge															1	-0.09	0.71**	0.07	0.06
16. ender																1	-0.02	-0.04	-0.07
17. rade																	1	0.12*	0.10
18. ather																		1	0.55**
19. other																			1
Mean	3.32	2.42	4.06	3.75	3.91	2.87	3.15	2.80	2.65	3.42	3.22	3.39	2.86	3.32	11.17	0.54	4.96	2.71	2.81
SD	1.26	1.25	0.88	0.90	0.83	1.14	0.45	0.53	0.48	0.85	0.93	0.81	0.36	0.80	1.00	0.50	0.82	0.84	0.79
Min	3.14	2.10	3.66	3.48	3.48	2.10	2.96	2.68	2.46	3.29	3.18	1.75	1.80	1.33					
Max	3.56	2.73	4.24	3.78	4.24	3.56	3.21	2.89	2.84	3.58	3.27	5.00	4.00	5.00					
Skewness	-0.22	0.52	-0.70	-0.26	-0.44	0.18	0.12	-0.44	0.40	0.20	0.18	0.18	0.25	0.24	0.62	-0.16	0.07	-0.64	-0.62
Kurtosis	-1.19	-0.91	-0.58	-0.58	-0.67	-1.04	-0.00	0.51	0.27	-0.62	-0.36	-0.75	0.64	-0.35	2.87	-1.99	-1.50	-0.08	0.23

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

have no significant correlation with student engagement, except for introjected pairs and emotional engagement (r = 0.14, p < 0.05), although the relationship is weak.

Mediation Analysis

We used the PROCESS feature in SPSS version 24 to examine the role of SRL mediation in the relationship between adaptability and engagement. We also used covariate variables namely student grade, father's education level, mother's education level, age, and gender. The results of this analysis can be summarized in Table 3.

Table 3

Analysis of Covariate Variable

	Coeff.	SE	t	P	LLCI	ULCI
OUTCOME VARIABLE: SELF REGULATION R^2 = 0.25, F(6, 33) = 18.27, p < 0.001						
Constant	3.13	0.50	6.32	0.00	2.16	4.15
Adapt	0.44	0.05	8.89	**0.00**	0.34	0.53
Age	0.00	0.06	0.04	0.97	-0.11	0.11
Gender	0.11	0.08	1.34	0.18	-0.05	0.26
Grade	-0.21	0.07	-3.12	**0.00**	-0.34	-0.08
Father	0.10	0.06	1.84	0.07	-0.01	0.21
Mother	-0.18	0.06	-3.06	**0.00**	-0.30	-0.06
OUTCOME VARIABLE: ENGAGE, R^2 = 0.14, F(7, 33) = 7.41, p < 0.001						
Constant	2.09	0.23	8.29	0.00	1.59	2.58
Adapt	0.10	0.03	3.66	**0.00**	0.05	0.15
Self	0.06	0.03	2.38	**0.02**	0.01	0.12
Age	0.01	0.03	0.28	0.78	-0.05	0.06
Gender	0.13	0.04	3.31	**0.00**	0.05	0.20
Grade	0.02	0.03	0.59	0.61	-0.05	0.08
Father	-0.00	0.03	-0.06	0.95	-0.05	0.05
Mother	0.00	0.03	0.15	0.88	-0.05	0.06

Note: Indirect effect(s) of X on Y:

	Effect	BootSE	BootLLCI	BootULCI
SELF	0.03	0.01	0.01	0.05

Note:
Coeff is the Coefficient Value of each variable; SE stands for Student Engagement; LLCI stands for Lower Level Confidence Interval; ULCI stands for Upper Level Confidence Interval; BootSE stands for Bootstrapping Student Engagement; BootLLCI stands for Bootstrapping Lower Level Confidence Interval; BootULCI stands for from the Bootstrap Top Level Confidence Interval.

Table 3 shows the data from the mediation analysis. The regression model describes a significant measure of variance in both self-regulation (R^2 = 0.25, F(6, 33) = 18.27, p < 0.01), and student engagement in online mathematics learning R^2 = 0.14, F(7, 33) = 7.41, p < 0.01). Table 3 also explains that path a, adaptability significantly predicts students' self-regulation with b = 0.44, p < 0.01. Track c' (direct effect) is also significant (b = 0.10, p < 0.01); that is, adaptability influences student engagement in online mathematics learning. Track b, namely student self-regulation, has a significant prediction on student engagement in online mathematics learning (b = 0.06, p < 0.05). Second, Table 3 also shows evidence for the mediation hypothesis of the self-regulation of the relationship between adaptability and student engagement is also significant (b = 0.03, BootLLCI = 0.01 and BootULCI = 0.05). Indirect effect (a*b) is significant because the bootstrap confidence interval does not include zero.

Table 3 also shows the grade of the covariate variable (b = -0.21, $p < 0.05$) and the mother's level of education (b = -0.18, $p < 0.05$); both have a negative and significant prediction on students' self-regulation. As for student engagement, only the gender variable has a positive and significant prediction (b = 0.13, $p < 0.05$).

We also conducted parallel mediation, which analyzed the mediating role of two intrinsic and extrinsic SRL factors in the relationship between adaptability and engagement. The analysis is to discover which SRL factors play a significant role in the relationship between adaptability and student engagement. The analysis using the PROCESS feature in SPSS using the same covariate variables.

The analysis results indicate that pathway adaptability has a significant positive effect on both intrinsic student self-regulation (b = 0.50, p < 0.01) and extrinsic self-regulation (b = 0.37, p < 0.01). This means that higher levels of pathway adaptability are associated with increased intrinsic and extrinsic self-regulation levels. Regarding student engagement, only the intrinsic factors show a significant positive relationship (b = 0.12, p < 0.01), indicating that higher levels of intrinsic engagement are associated with greater student engagement. On the other hand, the extrinsic factors are found to be insignificant in predicting student engagement (b = -0.01, p = 0.57), suggesting that they do not significantly influence student engagement.

Total indirect effects mediated by intrinsic or extrinsic factors together are significant (b = 0.06, BootLLCI = 0.03 and BootULCI = 0.09), while only indirect effects mediated by intrinsic factors are significant (b = 0.06, BootLLCI = 0.03 and BootULCI = 0.09).

The analysis results also show that all covariates except age variables significantly predict student engagement and self-regulation. Furthermore, similar to previous findings, grade (b = -0.19, $p < 0.05$) and mother's education level (b = -0.16, $p < 0.05$) both had a negative and significant predict on students' intrinsic self-regulation ability. These two covariate variables are also significant to the extrinsic factors of self-regulation.

Discussion

This study aims to investigate the role of self-regulation in the relationship between adaptability and engagement of elementary school students in online mathematics learning. The findings answered the research questions: (1) How does adaptability predict self-regulation? (2) How does self-regulation predict student engagement? (3) How does adaptability predict student engagement either directly or through the mediation of self-regulation? We also examined whether the covariate variables, namely gender, age, and education levels of the mother and father, influence self-regulation and student engagement. In addition, this study also validated the instruments that we had adapted according to the context of the study.

The findings of research question one demonstrate that adaptability significantly influences self-regulation, including intrinsic and extrinsic regulation factors. This aligns with several researchers who state that adaptability is part of self-regulation (Holliman et al., 2018; Martin et al., 2013), specifically related to coping with situational uncertainty and novelty. Thus, adaptability is useful for monitoring, directing, and managing thinking and behavior to lead to the goals to be achieved in diverse situations (Martin et al., 2013). This finding is further supported by Xu's (2022) research on the adaptation of online learning to students' self-regulation during the COVID-19 period. Xu (2022) emphasizes the importance of self-regulation in managing emotions, behaviors, and thoughts, highlighting that the shift to online learning necessitates a quick adaptation to self-regulation, particularly for students accustomed to traditional classroom settings.

The findings of research question two reveal a significant and positive relationship between self-regulation and student engagement in online mathematics learning. This finding is consistent with the study conducted by Sun & Rueda (2012), who investigated 203 students taking online classes and found that self-regulation positively influenced cognitive, emotional, and behavioral engagement. In the context of children's development, self-regulation is a strong predictor of student engagement (Jahromi et al., 2013). Children with higher self-regulation abilities are more likely to overcome challenges, regulate their emotions and behavior, and be accepted by their peers, leading to increased attention to learning opportunities and a desire to be actively involved in the learning process (Drake et al., 2014). Therefore, a higher degree of self-regulation in online learning can facilitate students to manage time, stay disciplined, set goals, engage in metacognition, adapt to new situations, and seek feedback for effective learning and overcoming challenges. Self-regulation is closely intertwined with behavioral, emotional, and cognitive engagement. Bandura's cognitive theory posits that learning occurs through reciprocal interactions among personal, behavioral, and environmental factors. Personal factors contribute to learning, including self-efficacy, self-regulation, and interests influenced by teachers, parents, and the surrounding community. Therefore, it can be concluded that self-regulation is crucial in fostering high levels of student engagement in online learning.

Our findings further indicate that adaptability has a significant positive prediction on student engagement both directly and through the mediation of student self-regulation. This finding reinforces previous evidence by showing that there is a positive relationship between adaptability and student engagement in various modes of mathematics learning (Collie & Martin, 2017). Previous studies showed that adaptability not only directly predicts student engagement but also affects student engagement through the mediation of positive academic chains and negative emotions. Adaptability predicts student engagement; when students are faced with new situations (face-to-face learning to online learning), they will tend to change the behavior, emotions, and cognition (Zhang et al., 2021). Previous research has indicated that emotions play a crucial role in the relationship between adaptation and student engagement within the educational setting (Chen et al., 2020; Jiang et al., 2020). When students are able to adapt well, they experience positive emotions such as joy and pride.

Conversely, students who experience negative emotions like anxiety and boredom tend to struggle with adaptation. These negative emotions act as barriers, hindering active participation in the learning process. Specifically, in the context of online mathematics learning, adaptability refers to the ability to employ strategies that assist students in navigating new challenges or changes that may arise (Martin et al., 2013). Students who possess strong adaptability tend to utilize their self-regulatory abilities to effectively manage their thoughts, behaviors, and emotions. Consequently, they are more likely to engage cognitively, behaviorally, and emotionally in learning mathematics online (Collie & Martin, 2017).

The covariate variables, specifically the grade level and the level of the mother's education, have a significant and negative impact on students' self-regulation. This means that their self-regulation tends to decrease as the student's grade level increases. Similarly, a higher level of education for mothers predicts a negative effect on their children's self-regulation. These findings are surprising as they reject our initial hypothesis, which suggested that higher levels of maternal education and higher grades would lead to increased self-regulation in students. One plausible explanation for these results is that mothers with higher education often have full-time jobs, leaving them with less time to support their children's learning (Purnomo et al., 2022). This lack of support can influence children's habits and ability to regulate their own learning, as previous studies have emphasized the importance of parental involvement in shaping parenting concepts (Purnomo et al., 2022; Silinskas & Kikas, 2019), as well as their involvement in the classroom (Yoppy Wahyu Purnomo et al., 2021). The negative relationship between grade level and self-regulation is indeed intriguing. Although studies have shown that self-regulation typically improves with age (Orgeta, 2009), individual personality traits also play a role in its development (Reed et al., 2020). Further investigation into students' personality types could provide additional insights into this relationship.

Conclusion

This research suggests that adaptability plays a crucial role in predicting students' ability to regulate themselves. Self-regulation, in turn, positively and significantly impacts students' active participation in online mathematics learning. Additionally, adaptability, directly and indirectly, affects student engagement, with the indirect effect mediated by student self-regulation. In addition to the three primary conclusions mentioned above, this study confirms the validity and reliability of the instruments adopted in Bahasa, Indonesia.

Other findings conclude that a number of covariate factors substantially impact self-regulation and student engagement. For example, mother education level significantly and negatively impacts students' self-regulation. We conclude that parental involvement is significant for students' engagement and the development of self-regulation even for online learning. The quality of parental involvement is related to students' self-concept and engagement in online mathematics learning. It is also important for schools to provide opportunities for parents, teachers, and the school itself to improve communication related to school programs, increase parents' knowledge and skills, and/or emotional closeness between teachers, parents, and students.

The study is not without its limitations. In the current study, only upper grades students were used as study participants. Future research needs to examine whether the lower and the upper elementary grades have significant differences concerning the variables studied and to expand the range of samples taken to increase generalizability. Additionally, the converse relationship between students' grade level and their self-regulation level needs to be examined in relationship with personality characteristics.

We are also limited to focusing on gender, grade, grade level, father and mother education levels, student age, and student gender. Future researchers may consider other covariate variables such as socioeconomic status or family income. Socioeconomic status or family income is indeed a relevant covariate to consider, as it can significantly impact students' access to resources and support for online mathematics learning. Socioeconomic status encompasses various factors such as income, occupation, and education level within a family. It has been shown to influence students' access to technology, internet connectivity, learning materials, and supportive learning environments. These factors can directly impact students' opportunities and experiences in online mathematics learning.

The findings regarding students' self-regulation and adaptability in online learning have important implications for their engagement in both home and online classroom settings. To cultivate self-regulation and adaptability in both home and online classroom settings, consider creating a supportive and structured learning environment, teaching self-regulation strategies explicitly, promoting metacognitive awareness, encouraging self-directed learning, and supporting the development of time management skills. Establish clear routines, resources, and expectations to support student engagement, and encourage students to take ownership of their learning and set goals. Educators can help students develop essential skills for effective learning and adaptability by fostering autonomy and promoting self-directed learning. Engage students in online learning environments by managing their time effectively, cultivating a growth mindset, promoting collaborative learning experiences, utilizing interactive and varied instructional methods, and providing regular feedback and support. By embracing challenges and setbacks, educators and parents can enhance student engagement and improve learning outcomes. By incorporating diverse learning materials, providing constructive guidance, and offering timely feedback, educators and parents can effectively cultivate self-regulation and adaptability skills in both home and online classroom settings.

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