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Analysis of factors that influence student engagement in mathematics learning

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ABSTRACT

Introduction. Student engagement in mathematics learning is a form of active student participation in mathematics learning, both learning activities in mathematics class and outside mathematics class. Several studies state that student engagement consists of cognitive, behavioural, emotional, and contextual aspects. Therefore, analyzing the four factors related to student engagement is necessary. In addition, an instrument that comes from the four dimensions is needed to measure student engagement. This needs to be done because there has not been much research that focuses on the development of Student Engagement instruments derived from 4 dimensions. For this reason, student engagement is very important so that the learning process can be achieved. *This study aims* to confirm student engagement comes from four domains: cognitive engagement, behavioural engagement, emotional engagement, and contextual engagement in mathematics learning.

Study participants and methods. This research is a quantitative study involving 375 of 10th in senior high school students in the city of Malang in Indonesia. They were selected of purposive sampling. The instrument used is the Student Engagement questionnaire, which consists of four indicators: cognitive engagement, behavioural engagement, emotional engagement, and construct engagement. Data analysis used Confirmatory Factor Analysis assisted by the Smart Partial Least Square version 3.0.

Results. The research results show that student engagement is reflected by four forming dimensions: cognitive, behavioural, emotional, and contextual. A total of 12 items out of 16 items prepared have been constructed in student involvement and declared valid. This result was obtained from the loading factor of 2 items in the cognitive aspect, obtained at more than 0.700 with an average variance extracted of 0.649 > 0.500; the loading factor of the three items in the behavioural aspect was obtained at more than 0.700 with an average variance extracted of 0.761 > 0.500; the loading factor of the three items on the emotional aspect was obtained at more than 0.700 with an average variance extracted of 0.599 > 0.500; and the loading factor of the four items in the contextual aspect was obtained at more than 0.700 with an average variance extracted of 0.666 > 0.500. In addition, a reliability index of 0.878 was also obtained for 12 items that were declared valid. The findings of this study include obtaining a student engagement in mathematics learning questionnaire consisting of 12 items from 4 dimensions: cognitive, behavioural, emotional, and contextual.

Conclusion. Student engagement is one of the essential aspects of mathematics learning, and it has an abstract nature. Engaged students will have a sense of joy (vigour) in learning at school, in groups, or independently at home. The results of this study showed that student engagement was confirmed to come from cognitive, behavioural, emotional, and contextual aspects. For this reason, the student engagement instrument obtained in this study can be used to reveal the characteristics of engaged students. The study results obtained that from 12 valid items, a loading factor of more than 0.5 was obtained for each aspect and a reliability index of 0.878.

KEYWORDS

analysis factors, confirmatory factor analysis, mathematics learning, student engagement

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INTRODUCTION

The International Commission on Education for the Twenty-first Century (UNESCO) considers it essential to change the education paradigm to include all-around human development [1; 2]. This can be seen in the four pillars of education, which include learning to gain knowledge and to carry out further learning (learning to know), learning to have essential competencies in dealing with different work situations and teams (learning to do), learning to actualize oneself as an individual with a personality that has balance and personal responsibility (learning to be), and learning to be able to appreciate and practice conditions of mutual dependence, diversity, understanding and internal peace between nations (learning to live together) [3; 4]. Besides that, the National Education Association also offers four primary skills: critical thinking and problem-solving, creativity and innovation, communication, and collaboration [5; 6]. For this reason, education today not only prioritizes cognitive abilities but also requires student involvement so that students have 21st-century skills to prepare for life in the future.

Education is oriented toward test scores and pays attention to mastering various skills adapted to the many needs of the 21st century [7; 8]. Education is a process to change human behaviour in the desired direction with the hope that changes in behaviour can positively affect life and achieve a better life in the future with a critical and systematic mindset [9; 10]. Therefore, learning in the 21st century is not only done through listening to material, writing material, and doing assignments but also by involving mental processes in the brain [11; 12].

This learning can be implemented by helping students obtain relevant knowledge to face future challenges [13]. 21st-century learning enables students to develop applicative knowledge skills in real-world situations [14; 15]. 21st-century learning can help students understand the world that involves direct experience, interaction, and social context [16], help learners understand the reasons for implications, and strengthen critical thinking and self-reflection [17; 18]. So, the focus of learning in the 21st century is to help students develop themselves to achieve success.

In the 21st century, mathematics education has undergone many significant transformations. This change is caused by massive technological developments and a shift in learning paradigms [11; 12]. The Covid pandemic presents its challenges, the impacts of which are felt to this day, such as learning loss [19; 20]. Even though we realize it or not, this pandemic has caused learning to provide significant positive changes, such as learning using e-learning platforms and a hybrid model [21; 22].

Based on the Program for International Student Assessment survey in 2022, Indonesia is ranked 68th out of 81 participating countries with a mathematics score of 379, a science 398, and a reading of 371 [23; 24]. The results obtained are still categorized as low. In PISA 2022, the mathematics assessment focused on students' mathematical skills, namely mathematical reasoning, including critical thinking skills, problem-solving, and higher-order thinking Skills [25; 26]. The results of PISA 2022 generally show that there has been a steep learning loss globally in mathematics, science, and reading for four years (2018-2022), the leading cause being the impact of the COVID-19 pandemic. Assessments carried out by PISA explore how well students can solve complex problems, think critically, and communicate effectively [27; 28]. So, PISA prepares students to develop 21st-century skills that are important for them, namely preparing themselves to face real life and achieve success in the future (learning for transfer).

Technological developments are like a double-edged sword [29; 30]. One side is used for positive things and the other harms students. On the positive side, technology in learning plays a significant role in mathematics education, such as the emergence of applications, software, and online learning platforms, thereby changing students' character into digital natives and those with visual tendencies. This technology follows the principles of mathematics learning, which provides the broadest possible opportunities for students to construct mathematical knowledge through individual learning, learning in small groups, or learning in a whole class atmosphere [31]. This also states that student participation in interactive learning is carried over during learning, so they are accustomed to being involved in productive interactions and high-level mathematical thinking.

Technological developments in mathematics learning also influence student engagement. Such a conceptual framework states that student engagement is greatly influenced by developments in technology used in education [32; 33]. However, there is still a gap in conceptualizing technology in learning because technological developments are increasingly rapid without being matched by existing educational developments [32]. However, this condition does not deny technology's inherent role in education and the potential to engage students in learning [34; 35]. Previous researchers stated that students are more interested in learning if the material delivered by the teacher is presented using technology such as e-learning, interactive media, or other media that use technology [36; 37].

However, several experts state that the importance of student engagement will determine the role of students in transforming objects [38; 39]. Students who are engaged will have a sense of enjoyment in studying at school, studying in groups, or studying independently at home [40; 41]. The feeling of enjoyment in learning is the first step that must be awakened because learning without being driven by a sense of joy in carrying out these activities will not be effective. Key factors that influence student engagement in learning include motivation, attention, intellectual effort, attitude, personality, effort drive, self-confidence, interaction, active learning, and time commitment [42; 43]. So satisfaction, relevance of the material, and feedback from friends and teachers are needed during learning. This is supported by previous research, which states that student engagement is significant in achieving learning success [44; 45].

There are four domains of student engagement: cognitive engagement, behavioral engagement, emotional engagement, and contextual engagement [46; 47]. Cognitive engagement consists of actions or mental processes that occur during mental processes that occur during the learning process. Behavioral involvement includes physical activity that shows interaction with other people or activities related to solving problems during learning [47; 48]. Emotional involvement refers to the level of satisfaction as evidenced by positive feelings and enthusiasm during learning [44; 46]. Contextual Engagement includes settings that can be linked to anticipated, personal, and relevant communications [47].

Based on this, this research aims to confirm student engagement comes from four domains: cognitive engagement, behavioral engagement, emotional engagement, and contextual engagement in mathematics learning. We believe student engagement is significant in achieving the learning process, including mathematics learning. The principles of mathematics learning provide the broadest possible opportunities for students to construct their knowledge through individual learning and group learning in mathematics classes [49; 50] and improve reasoning, communication, connection, representation, and problem-solving skills [51].

METHODS

This quantitative research aims to analyze and test the factors influencing student engagement in mathematics learning. Student engagement is a form of active student participation in activities at school, both inside the classroom and outside the classroom, such as exerting effort, enthusiasm, feelings of belonging, paying attention and interest, concentration, and complying with school regulations [47; 48]. So that the objectives of this research can be achieved, the following factors that influence student engagement include the dimensions of cognitive engagement, behavioral engagement, emotional engagement, and contextual engagement.

The population in this study were all class X high school students in Malang City, Indonesia. The sample size in this study was 375 students of 10th in senior high school taken using a purposive sampling technique. They are spread across public senior high schools in Lowokwaru, Malang, public senior high school number 7 Malang, public senior high school number 9 Malang, and senior high school of Brawijaya Smart School. The reason for selecting these three schools was because these schools were in the top 10 best in the city of Malang, had the same student input, and had the same learning facilities.

The instrument used in this research is a student engagement questionnaire, which consists of 4 dimensions, namely cognitive engagement (A), behavioral engagement (B), emotional engagement (C), and contextual engagement (D) [46; 47]. The four dimensions that have been determined are then explored in 16 items, as seen in Table 1.

Table 1

Dimensions of student engagement

Dimensions	Indicators	Item
Cognitive engagement (A)	Cognitive engagement is limited to activities related to a person's efforts to learn new material.	A1, A2, A3
behavioral engagement (B)	Behavioral engagement includes the effort and energy devoted to interacting with other students and the mathematics teacher, specifically to completing mathematics tasks, such as homework for a mathematics lesson.	B4, B5, B6, B7, B8, B9
emotional engagement (C)	Emotional involvement includes a measure of feelings and reflective thoughts about the value of mathematics lessons offered in learning compared to actions.	C10, C11, C12
contextual engagement (D)	Contextual engagement will be shaped by communication and concepts based on understanding and cues from other perceptions.	D13, D14, D15, D16

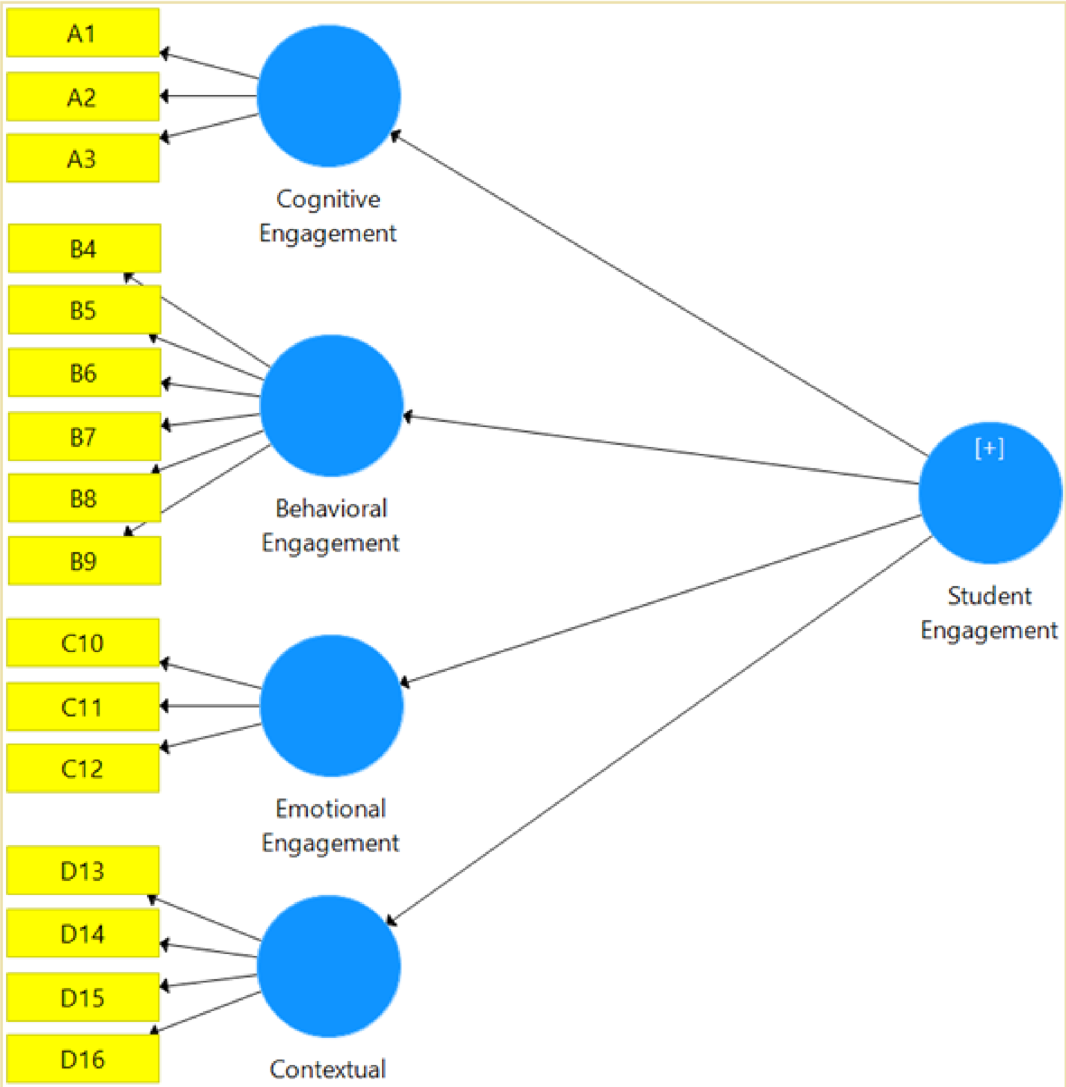

Figure 1 Confirmatory factor analysis model of student engagement

The Student Engagement Questionnaire was prepared using a 5-point Likert scale as a statement choice. Because this questionnaire is structured into items with positive values, the five choices are 5 to represent strongly agree, 4 to represent agree, 3 to represent undecided, 2 to represent disagree, and 1 to represent strongly disagree. Before use, three experts empirically validated the questionnaire in learning technology, mathematics learning strategies, and the learning environment.

Experts in learning technology aim to analyze how their knowledge, skills, and experience are used or applied in learning activities to improve their teaching and learning experience. Experts in Mathematics learning strategy have an essential role in taking measurements related to practical approaches, techniques, and methods in teaching and learning mathematics and designing engaging, relevant, and meaningful learning experiences for students. Learning environment experts measure how the physical and social environment around students can influence the student learning process and understand the importance of creating a learning environment that is supportive, stimulating, and can provide adequate learning facilities for all students. The three validators appointed have a doctoral scientific background that matches their expertise and an academic background of at least an associate professor. The assessment results carried out by the three validators showed that the Student Engagement questionnaire consisting of 4 dimensions obtained valid instrument results and was suitable for data collection.

After the data is collected, the next stage is data processing and analysis using Confirmatory Factor Analysis. This analysis uses the help of the Smart Partial Least Square (Smart-PLS) computer program version 3.0. Figure 1 is a confirmatory factor analysis model of student engagement. Confirmatory factor analysis is used because this analysis involves the specification and estimation of one or more putative factor structure models, each of which proposes a set of latent variables (factors) to account for the covariance among a set of observed variables [52; 53].

RESEARCH RESULTS

As stated in the previous section, the Student Engagement questionnaire was validated by three people who were considered experts with a doctoral scientific background and an academic background of at least an associate professor. The validation process is carried out through three stages, namely, first assessment, revision, and second assessment. In the initial evaluation, it was found that all validators agreed that the Student Engagement questionnaire needed improvement, such as (a) the instructions for filling out the questionnaire were not clear, (b) the assessment aspects were not appropriate, (c) the sentence structure gave rise to multiple interpretations, and (d) the language used not yet communicative. In the second stage, revisions were made based on input from the validators. After corrections have been made, the questionnaire is handed back to the validators for the second assessment. The final assessment results show that the questionnaire is valid and appropriate in terms of content, so it needs to be tested empirically.

Empirical testing is carried out to see whether there is a parallel between content validity and empirical validity. For this reason, analysis needs to be carried out using Confirmatory Factor Analysis. The smart PLS 3.0 program assists in the first calculation of Confirmatory Factor Analysis. The calculation results obtained are as in Figure 2 and Table 2.

Table 2

Loading factor for each item and average variance extracted for student engagement

Dimensions	Item	Loading Factors	Average variance extracted
Cognitive engagement (A)	A1	0.240	0.471
	A2	0.838	
	A3	0.896	
Behavioral engagement (B)	B4	0.560	0,521
	B5	0.709	
	B6	0.609	
	B7	0.640	
	B8	0.803	
	B9	0.765	

Emotional engagement (C)	C10	0.781	0,595
	C11	0.802	
	C12	0.862	
Contextual engagement (D)	D13	0.791	0,665
	D14	0.768	
	D15	0.767	
	D16	0.759	

So far, experts think that an indicator can be declared to meet convergent validity and have a high level of validity if the outer loading value is at least 0.70 [53; 54]. Convergent validity means that indicators/dimensions represent one latent variable and are the basis for that latent variable [55; 56]. However, there is a simpler expert opinion stating that convergent validity is the correlation between the reflexive indicator scores and the latent variable scores [57; 58]. Referring to this condition, based on Figure 2, it is known that the four components of the student engagement construct, namely cognitive engagement (A), behavioral engagement (B), emotional engagement (C), and contextual engagement (D), have items that cannot yet reflect each component in the student engagement construct, even though it already has a loading factor coefficient of more than 0.7. This is because item A1 for the Cognitive engagement construct has a loading factor of less than 0.70 (see Figure 2). Apart from that, items B4, B6, and B7 also do not reflect the behavioural engagement construct (B) because they have a loading factor of less than 0.700 (see Figure 2).

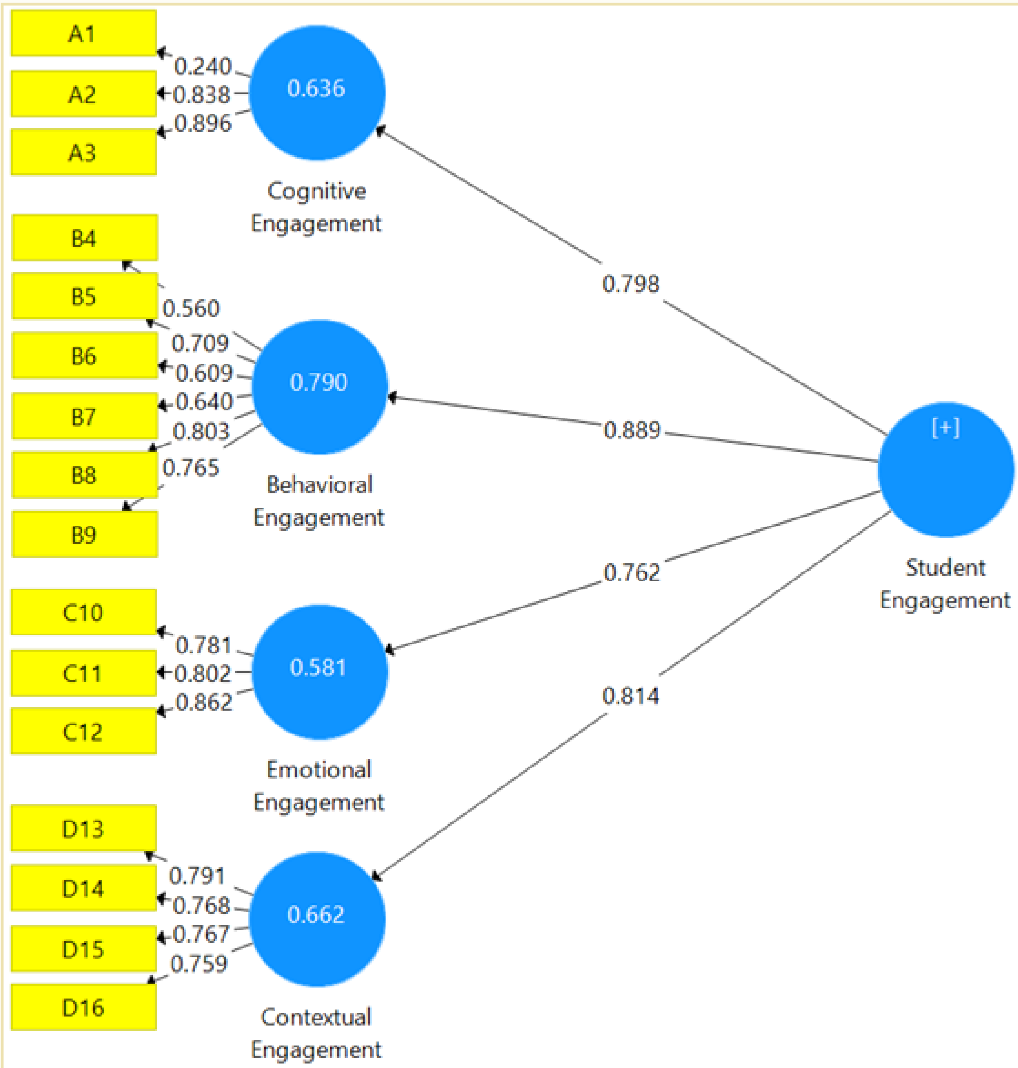

Figure 2 Loading factor confirmatory factor analysis is the first calculation of student engagement

Apart from considering the loading factor coefficient, each dimension representing a construct can also be seen from the average variance extracted coefficient. This is in line with the opinion which states that an indicator can be declared to meet convergent validity and have a high level of validity if the outer loading value is at least 0.70 and the Average Variance Extracted (AVE) value is at least 0.50 [59; 60]. From this statement, it can be concluded that behavioral engagement (B), emotional engagement (C), and contextual engagement (D) have an average variance extracted for both dimensions of more than 0.5. However, cognitive engagement has poor convergent validity because it has an Average Variance Extracted of less than 0.5.

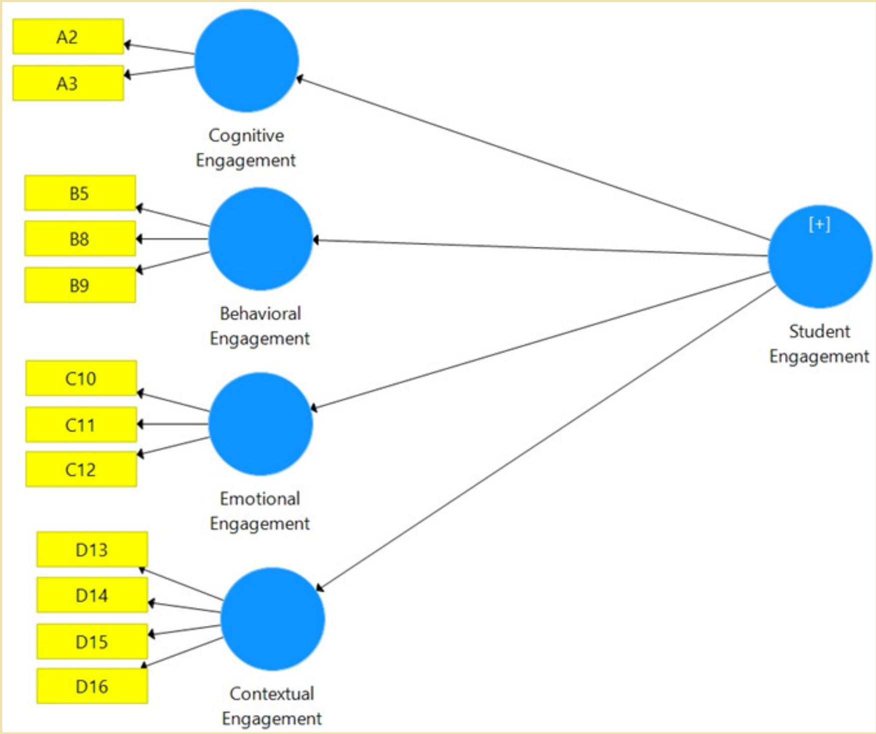

Figure 3 Confirmatory factor analysis modified of student engagement

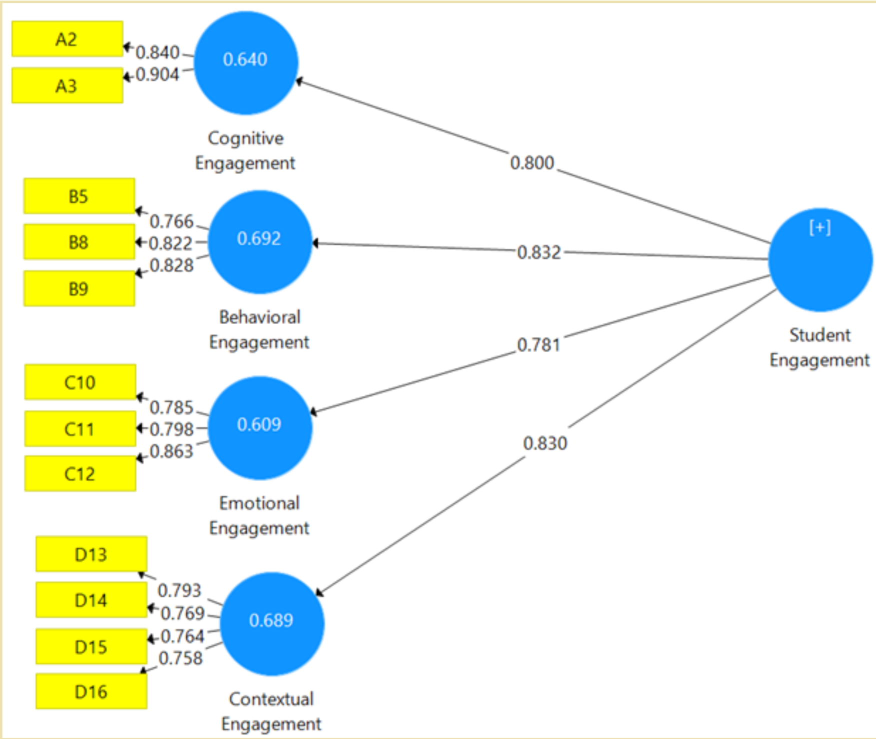

Figure 4 Loading factor confirmatory factor analysis modified of student engagement

Based on the results of calculations carried out as summarized in Figure 2 and Table 2, it can be seen that the dimensions of cognitive engagement (A), behavioral engagement (B), emotional engagement (C), and contextual engagement (D) cannot yet reflect the student engagement variable. This is because the loading factor coefficient was found for the items to be less than 0.7 (items A1, B4, B6, and B7), and the AVE coefficient was found for the dimensions to be less than 0.5 (namely, the cognitive engagement dimension). Based on this condition, modifications need to be made. Modifications are made based on items that have a loading factor of less than 0.7 by eliminating items A1, B4, B6, and B7 in the calculation process (see Figure 3). The results of the modified Confirmatory Factor Analysis calculations can be seen in Table 3 and Figure 4.

Based on Figure 3, it is known that the four components of the student engagement construct have items that can reflect each component of the student engagement construct. This is because all items have a loading factor coefficient of more than 0.7 (see Figure 3). By looking at the Average variance extracted coefficient in Table 3, it is found that cognitive engagement (A), behavioral engagement (B), emotional engagement (C), and contextual engagement (D) have good convergent validity for the student engagement variable because they have Average Variance Extracted more than 0.5.

Table 3

Average variance extracted of student engagement based modification

Dimensions	Item	Loading Factors	Average variance extracted
Cognitive engagement (A)	A2	0.840	0.649
	A3	0.904	
Behavioral engagement (B)	B5	0.766	0.761
	B8	0.822	
	B9	0.828	
Emotional engagement (C)	C10	0.785	0,595
	C11	0.798	
	C12	0.863	
Contextual engagement (D)	D13	0.793	0,666
	D14	0.769	
	D15	0.764	
	D16	0.758	

Based on the results of the confirmatory factor analysis calculation carried out for the first time and the modified confirmatory factor analysis results, it can be concluded that (a) the cognitive dimension of engagement (A) has good convergent validity on student engagement originating from items A2 and A3, (b) the behavioral dimension engagement (B) has good convergent validity towards student engagement which comes from items B5, B8 and B9, (c) the emotional engagement dimension (C) has good convergent validity towards student engagement which comes from items C10, C11 and C12, (d) the contextual engagement dimension (D) has good convergent validity on student engagement derived from items D13 to D16.

The reliability of the instrument can be seen from the results of calculating Cronbach's alpha coefficient obtained from the confirmatory Factor analysis output using SmartPLS. Based on Table 4, it is found that the coefficient of Cronbach's alpha is 0.878, and composite reliability is 0.900. Many experts state that an instrument is said to be good if the alpha and composite reliability coefficients are more than 0.7. The calculation results show that the alpha coefficient and composite reliability are more than 0.7, so it can be concluded that the student engagement instrument is reliable.

Table 4

Cronbach's alpha and composite reliability values of student engagement constructs

Construct	Cronbach's Alpha	Composite Reliability	Information
Student Engagement	0.878	0.900	Reliable

DISCUSSION

Student engagement in mathematics learning can refer to student engagement in mathematics learning activities in class. There are four components of student engagement: cognitive engagement, behavioral engagement, emotional engagement, and contextual engagement [47]. Cognitive engagement consists of actions or mental processes that occur during learning activities [44; 61]. However, some aspects of cognition have been combined with behavioral skills, collectively called skills, which refer specifically to students' academic skills. Another aspect of engagement is called interaction, which includes asking or answering questions, participating in group work, and completing homework. So cognitive engagement can refer to activities related to a person's efforts to learn the mathematical material being studied.

Behavioral engagement includes physical activities that involve interaction with other people in mathematics learning activities related to completing mathematics tasks [47; 62]. The conceptualization of behavior types relates to the amount of physical effort and energy devoted to the activity. Behavioral engagement may also include actions that develop a sense of belonging, as evidenced by relationships with students or teachers. These interactions have also been conceptualized as collaborative learning and student-teacher and student-student interactions that lead to quality relationships. Lastly, behavioral engagement includes the effort and energy devoted to interacting with other students and teachers in mathematics lessons and specifically to completing assignments given in mathematics lessons.

Emotional engagement refers to the level of satisfaction as evidenced by positive feelings and enthusiasm for the mathematics learning received [62; 63]. These positive feelings were also expressed as "students' desire to do their best" and the sense that learning mathematics is essential. The feeling that mathematics is relevant to students' lives represents another dimension of emotional engagement. This real-life relevance likely contributed to students' opinions about the level of enrichment of the mathematics learning experience. Emotional engagement is different from cognition or behavior because emotional engagement revolves around a measure of feelings and reflective thoughts about the value of the learning offered in a mathematics class versus action.

The contextual engagement component includes student self-regulation and can be linked to personal and relevant [47]. The components of contextual engagement do not fit into a cognitive, behavioural, or emotional framework but generally include aspects of involvement related to mathematics learning. A frequently emerging component of student engagement is academic performance, described as engagement about success in a course and earning high grades. Another common contextual component is student engagement with the institution [64]. Contextual engagement is also related to measuring how students' experiences shape themselves as individuals. This context will be shaped by communication and concepts based on understanding and other perceptual cues.

Student engagement in mathematics learning is not always easy to achieve. However, this is not impossible to achieve. Engagement requires extraordinary commitment on the part of teachers and students. Students must be willing to grow into thoughtful, open-minded individuals and eager to update professional developments regularly.

CONCLUSION

Based on the results of the analysis that has been carried out on the student engagement construct, it can be seen that student engagement is confirmed from 4 forming dimensions, namely cognitive engagement, behavioral engagement, emotional engagement, and contextual engagement. In addition, in this study, 12 student engagement items were found to be valid with a reliability index of 0.878. It is recommended to use 12 items based on cognitive, behavioral, emotional, and contextual dimensions to measure student engagement.

REFERENCES

1. Lee, J. C. K., & Yip, S. Y. W. (2021). Teacher education and role of educators under the context of educational change in the twenty-first century: Prospects and challenges. *Quality in Teacher Education and Professional Development*, (pp. 15-29). Routledge. DOI: 10.4324/9781003197973.
2. Reimers, F. M., & Chung, C. K. (2019). Teaching and learning for the twenty-first century: Educational goals, policies, and curricula from six nations. Harvard education press.
3. Elfert, M. (2019). Lifelong learning in Sustainable Development Goal 4: What does it mean for UNESCO's rights-based approach to adult learning and education? *International Review of Education, 65*(4), 537–556. DOI: 10.1007/s11159-019-09788-z.
4. Rieckmann, M. (2018). Learning to transform the world: Key competencies in Education for Sustainable Development. *Issues and trends in education for sustainable development, 39*(1), (pp. 39–59). UNESCO.
5. Suriswo, S., Aulia, F., & Utami, W. B. (2023). Development of the life skills learning model for elementary school students as strengthening the pancasila student profile. *Jurnal Teknologi Pendidikan, 25*(2), 315–322, 2023. DOI: 10.21009/jtp.v25i2.37532.
6. Erdogan, V. (2019). Integrating 4C Skills of 21st Century into 4 Language Skills in EFL Classes. *International Journal of Education and Research, 7*(11), 113–124, available at www.ijern.com
7. Kim, S., Raza, M., & Seidman, E. (2019). Improving 21st-century teaching skills: The key to effective 21st-century learners. *Research in Comparative and International Education, 14*(1), 99-117. DOI: 10.1177/1745499919829214.
8. Xu, S. R., & Zhou, S. N. (2022). The Effect of Students' Attitude towards Science, Technology, Engineering, and Mathematics on 21st Century Learning Skills: A Structural Equation Model. *Journal of Baltic Science Education, 21*(4), 706-719. DOI: 10.33225/jbse/22.21.706.
9. Anwar, L., Sa'dijah, C., & Murtafiah, W. (2024, February). The effect of peer review on the quality of developed numeracy problems: The case of Indonesian mathematics teacher candidates. *AIP Conference Proceedings, 3049*(1). DOI: 10.1063/5.0194846.
10. English, L. D., & J. Gainsburg, J. (2015). Problem solving in a 21st-century mathematics curriculum. *Handbook of international research in mathematics education* (pp. 325-347). Routledge. DOI: 10.4324/9780203448946.
11. Laksana, S. D., Setyosari, P., Praherdhiono, H., Kuswandi, D., & Jannan, D. (2024). The Effect of the Use of Digital Gamification and Metacognitive Skills on Students' Mathematics Solving Ability. *Pegem Journal of Education and Instruction, 14*(3), 117-125. DOI: 10.47750/pegegog.14.03.11.
12. Mustaqim, I., Setyosari, P., Kamdi, W., & Ulfa, S. (2024). Building the Foundation for Creativity and Collaboration: Knowledge Sharing Learning Models. *Jurnal Cakrawala Pendidikan, 43*(1), 262-272. DOI: 10.21831/cp.v43i1.60380.
13. Tan, O. S. (2021). Problem-based learning innovation: Using problems to power learning in the 21st century. Singapore: Gale Cengage Learning.
14. Wrahatnolo, T. (2018). 21st centuries skill implication on educational system. *IOP Conference Series: Materials Science and Engineering, 296*(1). DOI: 10.1088/1757-899X/296/1/012036.
15. Ah-Nam. L., & Osman, K. (2017). Developing 21st century skills through a constructivist-constructionist learning environment. *K-12 Stem Education, 3*(2), pp. 205–216. Available: https://www.learntechlib.org/p/209542/
16. Kuhlthau, C. C., Maniotes, L. K., & Caspari, A. K. (2015). Guided inquiry: Learning in the 21st century. California: Bloomsbury Publishing USA.
17. El-Senousy, H. (2020). E-Portfolio to Assess the 21 st Century Skills of Students in Smart E-Learning Environment. *International Journal for Quality Assurance, 3*(1). Available: https://ijqa.zu.edu.jo/eng/images/stories/year2019/07/Vol3_no1/133.pdf
18. Kong, S. C. (2015). An experience of a three-year study on the development of critical thinking skills in flipped secondary classrooms with pedagogical and technological support. *Computers & Education, 89*, 16-31. DOI: 10.1016/j.compedu.2015.08.017.

19. Barakabitze, A. A., William-Andey Lazaro, A., Ainea, N., Mkwizu, M. H., Maziku, H., Matofali, A. X., Iddi, A., & Sanga, C. (2019). Transforming African education systems in science, technology, engineering, and mathematics (STEM) using ICTs: Challenges and opportunities. *Education Research International, 2019*(1), 1–29. DOI: 10.1155/2019/6946809.
20. Saykili, A. (2019). Higher education in the digital age: The impact of digital connective technologies. *Journal of Educational Technology and Online Learning, 2*(1), 1–15. DOI: 10.31681/jetol.516971
21. Irfan, M., Kusumaningrum, B., Yulia, Y., & Widodo, S. A. (2020). Challenges during the pandemic: use of e-learning in mathematics learning in higher education. *Infinity Journal, 9*(2), 147-158. DOI: 10.22460/infinity.v9i2.p147-158.
22. Irfan, M., Suryaningrum, Ch. W., Pusporini, W., & Widodo, S. A. (2023). Online learning effect of post pandemic COVID-19: a survey at universities in Indonesian. *Perspektivy nauki i obrazovania = Perspectives of Science and Education, 61*(1), 575–588. DOI: 10.32744/pse.2023.1.34.
23. Organisation for Economic Co-operation and Development. (2023). PISA 2022. DOI: 10.31244/9783830998488
24. Wijaya, T. T., Hidayat, W., Hermita, N., Alim, J. A., & Talib, C. A. (2024). Exploring contributing factors to PISA 2022 mathematics achievement: Insights from Indonesian teachers. *Infinity Journal, 13*(1), 139-156. DOI: 10.22460/infinity.v13i1.p139-156
25. Ariati, C., & Juandi, D. (2022). Realistic Mathematic Education on Higher-Order Thinking Skill Mathematics of Students. *Kalamatika: Jurnal Pendidikan Matematika, 7*(2), 219–236. DOI: 10.22236/KALAMATIKA.vol7no2.2022pp219-236.
26. Utami, M. R. P., Zulkardi, Z., & Putri, R. I. I. (2024). Student’s critical thinking skills in solving PISA-like mathematics questions on quantity content. *AIP Conference Proceedings*. DOI: 10.1063/5.0201029.
27. She, H. C., Lin, H. S., & Huang, L. Y. (2019). Reflections on and implications of the Programme for International Student Assessment 2015 (PISA 2015) performance of students in Taiwan: The role of epistemic beliefs about science in scientific literacy. *Journal of Research in Science Teaching, 56*(10), 1309-1340. DOI: 10.1002/tea.21553.
28. Csapó, B., & Funke, F. (2017). The development and assessment of problem solving in 21st-century schools. *Education Research and Innovation: The nature of problem solving* (pp. 19–32). OECD. DOI: 10.1787/9789264273955-3-en
29. Kang, K. H., Jo, G. S., & Kang, J. (2015). External technology acquisition: a double-edged sword. *Asian Journal of Technology Innovation, 23(*1), 35–52, 2015. DOI: 10.1080/19761597.2015.1010265.
30. Khechine, H., & Lakhal, S. (2018). Technology as a double-edged sword: From behavior prediction with UTAUT to students’ outcomes considering personal characteristics. *Journal of Information Technology Education. Research, 17*, 63–102. DOI: 10.28945/4022.
31. Setianingsih, R., Sa’dijah, C., As’ari, A. R., & Muksar, M. (2018, December). Facilitating Classroom Discussion In Mathematics Instruction To Promote Students’ Understanding. *International Conference on Science and Technology* (pp. 810-818). Atlantis Press. DOI: 10.2991/icst-18.2018.165.
32. Shah, R. K., & Barkas, L. A. (2018). Analysing the impact of e-learning technology on students’ engagement, attendance and performance. *Research in Learning Technology, 26*. DOI: 10.25304/rlt.v26.2070.
33. Rashid, T., & Asghar, H. M. (2016). Technology use, self-directed learning, student engagement and academic performance: Examining the interrelations. *Computers in human behavior, 63*, 604-612. DOI: 10.1016/j.chb.2016.05.084.
34. Bond, M., & Bedenlier, S. (2019). Facilitating student engagement through educational technology: Towards a conceptual framework. *Journal of Interactive Media in Education*, *2019*(1). DOI: 10.5334/jime.528.
35. Sutarto, S., Sari, D. P., & Fathurrochman, I. (2020). Teacher strategies in online learning to increase students’ interest in learning during COVID-19 pandemic. *Jurnal Konseling Dan Pendidikan, 8*(3), 129-137. DOI: 10.29210/147800.
36. Taat, M. S., & Francis, A. (2020). Factors Influencing the Students' Acceptance of E-Learning at Teacher Education Institute: An Exploratory Study in Malaysia. *International Journal of Higher Education, 9*(1), 133-141. DOI: 10.5430/ijhe.v9n1p133.
37. Alenezi, A. (2020). The role of e-learning materials in enhancing teaching and learning behaviors. *International Journal of Information and Education Technology, 10*(1), 48-56. DOI: 10.18178/ijiet.2020.10.1.1338.
38. Burke, P. F., Kearney, M., Schuck, S., & Aubusson, P. (2022). Improving mobile learning in secondary mathematics and science: Listening to students. *Journal of Computer Assisted Learning, 38*(1), 137–151. DOI: 10.1111/jcal.12596.
39. Lei, H., Cui, Y., & Zhou, W. (2018). Relationships between student engagement and academic achievement: A meta-analysis. *Social Behavior and Personality: an international journal, 46*(3), 517–528. DOI: 10.2224/sbp.7054.
40. Di Natale, A. F., Repetto, C., Riva, G., & Villani, D. (2020). Immersive virtual reality in K-12 and higher education: A 10-year systematic review of empirical research. *British Journal of Educational Technology, 51*(6), 2006–2033. DOI: 10.1111/bjet.13030.
41. Wester, E. R., Walsh, L. L., Arango-Caro, S., & Callis-Duehl, K. L. (2021). Student engagement declines in STEM undergraduates during COVID-19–driven remote learning. *Journal of microbiology & biology*

education, 22(1). DOI: 10.1128/jmbe.v22i1.2385.
42. Hekmat, A. M., Roghmal, S., Yaqubi, M. N., & Kamal, M. M. (2022). Development of Student Engagement in Higher Education. *Language in India, 22*(10). Available: http://languageinindia.com/oct2022/hEkmatstudentengagementfinal.pdf
43. Mekki, O. M., Ismail, A. M., & Hamdan, D. M. (2022). Student engagement in English language classes: An evaluative study. *Sohag University International Journal of Educational Research, 6*(6), 15-52. DOI: 10.21608/SUIJER.2022.253735.
44. Anjarwati, R., & Sa'adah, L. (2021). Student learning engagement in the online class. *English Journal of Merdeka: Culture, Language, and Teaching of English, 6*(2), 39-49. DOI: 10.26905/enjourme.v6i2.6128.
45. Headden S., & McKay, S. (2015). Motivation Matters: How New Research Can Help Teachers Boost Student Engagement. California: Carnegie Foundation.
46. Fatawi, F. (2020). Effect of online-based concept map on student engagement and learning outcome. *International Journal of Distance Education Technologies, 18*(3), 42–56. DOI: 10.4018/IJDET.2020070103.
47. Merkle, A. C., Ferrell, L. K., Ferrell, O. C., & Hair Jr, J. F. (2022). Evaluating E-book effectiveness and the impact on student engagement. *Journal of Marketing Education, 44*(1), 54-71. DOI: 10.1177/02734753211035162.
48. Pradana, M. D., Setyosari, P., Ulfa, S., & Degeng, M. D. K. (2024). Correlation of Learning Systems with Student Engagement and Learning Outcomes. *Al-Hayat: Journal of Islamic Education, 8*(1), 364-377. DOI: 10.35723/ajie.v8i1.518.
49. Retnowati, E., Ayres, P., & Sweller, J. (2017). Can collaborative learning improve the effectiveness of worked examples in learning mathematics? *Journal of educational psychology, 109*(5), 666. DOI: 10.1037/edu0000167.
50. Lo, C. K., Hew, K. F., & Chen, G. (2017). Toward a set of design principles for mathematics flipped classrooms: A synthesis of research in mathematics education. *Educational Research Review, 22*, 50-73. doi: 10.1016/j.edurev.2017.08.002.
51. Fasni, N., Turmudi, T., & Kusnandi, K. (2017). Mathematical Problem Solving Ability of Junior High School Students through Ang's Framework for Mathematical Modelling Instruction. *Journal of Physic Conference Series, 895*(1). DOI: 10.1088/1742-6596/895/1/012082.
52. Hidayat, W., Widodo, S. A., T. Syahrizal, T. (2023). The statistical thinking skill and adversity quotient of English pre-service teacher. *International Journal of Evaluation and Research in Education, 12*(1), 421–432. DOI: 10.11591/ijere.v12i1.24302.
53. Widodo, S. A., Dahlan, J. A., Harini, E., & Sulistyowati, F. (2020). Confirmatory factor analysis sosiomathematics norm among junior high school student. *International Journal of Evaluation and Research in Education, 9*(2), 448–455. DOI: 10.11591/ijere.v9i2.20445.
54. Ab Hamid, M. R., Sami, W., & Sidek, M. H. M. (2017). Discriminant validity assessment: Use of Fornell & Larcker criterion versus HTMT criterion. *Journal of physics: Conference series, 890*(1). DOI: 10.1088/1742-6596/890/1/012163.
55. Sobandi, A., Suryadi, E., Ramdhany, M. A., & Rasto, R. (2021). Knowledge management process, knowledge sharing, and teacher literacy skills at vocational high schools. *Cakrawala Pendidikan, 40*(3), 738-749. DOI: 10.21831/cp.v40i3.42489.
56. Weber, R. (2021). Constructs and Indicators: An Ontological Analysis. *MIS Quarterly, 45*(4). DOI: 10.25300/MISQ/2021/15999.
57. Cheah, J. H., Sarstedt, M., Ringle, C. M., Ramayah, T., & Ting, H. (2018). Convergent validity assessment of formatively measured constructs in PLS-SEM: On using single-item versus multi-item measures in redundancy analyses. *International journal of contemporary hospitality management, 30*(11), 3192-3210. DOI: 10.1108/IJCHM-10-2017-0649.
58. Ardi, N. (2020). Structural Equation Modelling-Partial Least Square to Determine the Correlation of Factors Affecting Poverty in Indonesian Provinces. In IOP Conference Series: Materials Science and Engineering. *IOP Publishing*. DOI: 10.1088/1757-899X/846/1/012054.
59. Haji-Othman, Y., & Yusuff, M. S. S. (2022). Assessing reliability and validity of attitude construct using partial least squares structural equation modeling. *International Journal of Academic Research in Business and Social Science, 12*(5), 378-385. DOI: 10.6007/IJARBSS/v12-i5/13289.
60. Yusoff, A. S. M., Peng, F. S., Abd Razak, F. Z., & Mustafa, W. A. (2020). Discriminant validity assessment of religious teacher acceptance: The use of HTMT criterion. *Journal of Physics: Conference Series, 1529*(1). DOI: 10.1088/1742-6596/1529/4/042045.
61. Nugroho, I. S., Kusumawati, E., & Wahyuningsih, D. D. (2021). Student engagement during pandemic COVID-19 and its implications for guidance and counseling. *KONSELI: Jurnal Bimbingan Dan Konseling, 8*(2), 135–144. DOI: 10.24042/kons.v8i2.8778.
62. Ginting, D. (2021). Student engagement and factors affecting active learning in English language teaching. *Voices of English Language Education Society, 5*(2), 215–228. DOI: 10.29408/veles.v5i2.3968.
63. Kahu, E. R. (2013). Framing student engagement in higher education. *Studies in Higher Education, 38*(5), 758–773. DOI: 10.1080/03075079.2011.598505.
64. Carini, R. M., Kuh, G. D., & Klein, S. P. (2006). Student engagement and student learning: Testing the linkages. *Research in Higher Education, 47*(1), 1–32. DOI: 10.1007/s11162-005-8150-9.

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