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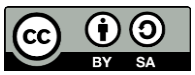

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Exploring the Impact of Peer Interaction and Self-Efficacy on Students' Engagement in Online Learning

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Abstract

This study investigated the impact of peer interaction and self-efficacy on student engagement in online learning among 100 tenth-grade students at SMAN 1 Mancak, Serang, Banten, Indonesia. Grounded in the Community of Inquiry (CoI) framework, the research explored how these factors influence student engagement in online learning environments. Specifically, it aimed to determine their individual and joint predictive power on student engagement. Employing a quantitative survey design and multiple linear regression, the study examined these effects on students' behavioral, emotional, and cognitive engagement. The questionnaire, a validated Likert-scale instrument, demonstrated strong internal consistency with Cronbach's alpha values exceeding 0.70 for all constructs. Findings revealed a strong positive correlation ($R = 0.722$, $R^2 = 0.521$) and confirmed that both peer interaction and self-efficacy significantly predicted student engagement, with comparable standardized beta coefficients indicating relatively equal contributions. These results underscore the critical roles of social connections and individual beliefs in fostering active participation in online learning. The study highlights the importance of designing online learning environments that facilitate meaningful peer interactions and enhance students' self-efficacy to improve engagement. While providing significant insights, this study acknowledges limitations such as its specific geographical focus and cross-sectional design.

Keywords: *Peer Interaction, Self-Efficacy, Student Engagement, Online Learning, COVID-19*

Introduction

Within a few months, millions of individuals around the world, including students in higher education, were profoundly affected by the COVID-19 pandemic, which was caused by a novel corona virus (Suryadi, 2022). The learning conditions in 2020/2021 were significantly different from previous years, as schools prior to the pandemic primarily conducted face-to-face learning (Herli Salim, 2022). The rapid transition to online learning environments, accelerated by global disruptions such as the COVID-19 pandemic, has significantly transformed the educational landscape (Chiu, 2021; Daniel, 2022).

Amid this shift, student engagement has emerged as a crucial determinant of academic success and learning continuity in virtual settings (Bolliger, D. U., & Martin, 2021; Zhang, K., Zhao, Y., Zhou, L., & Jiang, 2021)). In online education, engagement is not only shaped by instructional design and technology but also by psychosocial and interpersonal factors (Alqurashi, 2020). This study focuses on two pivotal variables: peer interaction and self-efficacy, and their influence on students' engagement in online learning contexts.

Peer interaction is a core element in online collaborative learning and plays a substantial role in shaping learners' cognitive and emotional involvement (Kuo, Y.-C., Tseng, T.-H., Yang, J.-M., & Yao, 2021; Phan, M. N., Valiente, C., & Ngu, 2021). It includes all forms of learner-to-learner communication such as group discussions, peer feedback, and cooperative projects (Deng, R., & Tavares, 2020). For the purpose of this study, peer interaction encompasses all forms of learner-to-learner communication and collaboration in online settings, measured through reported frequency and quality of interactions.

The absence of traditional classroom settings in online learning can sometimes limit spontaneous peer interaction, potentially affecting engagement (Dhawan, 2020). The Community of Inquiry (CoI) framework explicitly underscores the importance of social presence, which is significantly operationalized through peer interaction, as vital for sustained engagement (Garrison, D. R., Anderson, T., & Archer, 2021). Within this framework, positive peer interaction fosters shared knowledge construction, emotional support, and motivation, thereby directly enhancing learning engagement (Bayoumy, A. A. A., & Alsayed, 2021; Yang, F., Liu, S., Yu, Z., & Cheng, 2023). In contrast, poor peer interaction may lead to feelings of isolation and disengagement in digital environments (Li, C., & Wang, 2022).

Self-efficacy, as defined by Bandura, refers to individuals' beliefs in their capacity to execute behaviors necessary to produce specific performance attainments. In the context of online learning, this translates into learners' confidence in their ability to navigate digital tools, manage time, and maintain discipline for independent study (Irawan, A. W., Dwisona, D., & Lestari, 2020; Zhou, M., He, Q., & Brouwer, 2021). Despite the well-established link between self-efficacy and student engagement, some studies have pointed out that self-efficacy can be

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influenced by various factors, including prior online learning experience, technological skills, and the design of the online learning environment (Huang, R., Liu, D., Tlili, A., Yang, J., & Wang, 2017).

For instance, students who lack confidence in their ability to use online learning tools or navigate the online learning platform may experience lower self-efficacy and, consequently, reduced engagement (Saad, S., Said, A. M., & Al-Emran, 2020). Research consistently shows that students with higher online learning self-efficacy tend to be more engaged, persistent, and resilient in the face of academic challenges (Hodges, C. B., Moore, S., Lockee, B. B., Trust, T., & Bond, 2020; Lee, S., Choi, Y., & Kim, 2021). Self-efficacy supports not only behavioral engagement such as participation in forums but also emotional and cognitive engagement (Chen, P.-S. D., Lambert, A. D., & Guidry, 2023; Sun, L., Chen, J., & Zhang, 2021). These findings underscore the importance of fostering self-efficacy among online learners to enhance their engagement.

Student engagement, the dependent variable in this study, is a multidimensional construct comprising behavioral, emotional, and cognitive dimensions. In online education, engagement is often measured through indicators such as login frequency, discussion board activity, assignment submission, and reflective thinking (Dixson, 2021; Martin, F., Ritzhaupt, A. D., Kumar, S., & Budhrani, 2020). High levels of engagement are strongly associated with better academic outcomes, satisfaction, and retention in online learning (El-Sayad, G., Grainger, R., & Fullarton, 2021; Nguyen, 2021).

Student engagement is conceptualized as a multidimensional construct, comprising behavioral (e.g., participation in discussions), emotional (e.g., emotional interest), and cognitive (e.g., effort in understanding course content) involvement in online learning activities. However, online learning often suffers from low engagement rates due to technological, motivational, and social challenges (Zhao, C., Ullah, I., & Khan, 2023). Studies have examined how different online platforms and tools can either facilitate or hinder peer interaction and self-efficacy, thereby affecting student engagement (Martin, F., Ritzhaupt, A. D., Kumar, S., & Budhrani, 2020).

The impact of social presence, which is closely related to peer interaction, on student engagement has also been a focus of recent research; for instance, (Jiang, X., & Zhang, 2021) found that higher levels of social presence are associated with increased student engagement in online learning communities. Synchronous learning with ZOOM and asynchronous media using Google Classroom media are common alternatives in online learning (Suryadi, 2022).

Despite these valuable insights, several gaps persist in the literature. Firstly, while individual effects of peer interaction and self-efficacy have been explored, fewer studies have examined their combined impact within an integrated model, particularly concerning their interactive effects (Kim, J., Lee, J., & Lee, 2022; Phan, M. N., & Ngu, 2021). Secondly, much existing research on engagement often

overlooks its emotional dimension, focusing predominantly on behavioral and cognitive aspects (Hashim, H. A., Awang, H., & Salleh, 2020; Lopez, A., Robinson, T., & Lee, 2023), limiting a holistic understanding.

Thirdly, there is a distinct need for research in diverse educational contexts, especially in developing countries like Indonesia, where unique cultural and technological factors may influence these dynamics (Putri, R. S., Purwanto, A., Pramusinto, H., Setyaningsih, S., & Fahmi, 2022; Utami, N. W., Widodo, A., & Tabroni, 2023). Lastly, as online learning transitions beyond emergency measures, understanding these relationships in a post-pandemic, normalized online environment becomes crucial, moving beyond studies conducted during the peak of the crisis (Rachmatullah, A., Suryani, A., & Nurhayati, 2021; Tan, S. C., Li, J., & Koh, 2022). Previous studies have often relied on small, homogenous samples or single-course case studies, limiting the generalizability of findings (Heo, S., & Han, 2020; Song, L., Singleton, E. S., Hill, J. R., & Koh, 2024).

This research aims to provide a more nuanced understanding and contribute to the growing body of literature by offering a more comprehensive understanding of how peer interaction and self-efficacy jointly influence student engagement in fully online learning environments. First, it provides a more nuanced understanding of the role of peer interaction by examining its relationship with self-efficacy in the context of online learning engagement. Second, it investigates the potential moderating effect of self-efficacy, which can help explain how individual differences influence the impact of social factors on engagement.

Unlike previous studies that examined these variables separately, this research proposes an integrative model, allowing for the identification of direct and interactive effects (Aliyyah, R. R., Adawiyah, W. R., Garzia, M., Muslihudin, M., & Nurkhin, 2020; Wang, Q., Chen, W., & Anderson, 2021). Furthermore, this study provides a richer and more holistic measure of student involvement by including three dimensions of engagement behavioral, emotional, and cognitive addressing the conceptual limitations of studies that view engagement as a unidimensional construct (Lim, J., & Lee, 2023; Martin, F., & Bolliger, 2021; Miranda, D., Gaudioso, E., & Martínez, 2020; Redmond, J., Lock, J. V., Wieman, R., & Waycott, 2020).

Additionally, the study is conducted in the post-pandemic phase, offering insights into how students adapt to normalized online learning environments, beyond crisis-based education (Han, S., Shakhsi, S., & Jung, 2022; Trisnawati, M., Suharsono, N., & Nurhayati, 2024). Lastly, this research adds cultural and contextual depth by focusing on students from a Southeast Asian country, contributing to the diversification of online education research, which has been largely dominated by Western contexts (Lee, J., & Jung, 2022; Nugroho, A., Sutama, S., Prayitno, H. J., & Nurhadi, 2023).

The originality of this research lies in its integrated approach, which considers the interplay between social and psychological factors in shaping online learning engagement, and in its comparative analysis of the relative importance of

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peer interaction and self-efficacy. The primary objective of this study is to explore the impact of peer interaction and self-efficacy on students' engagement in online learning environments. By identifying the individual and combined effects of these variables, this study aims to inform instructional design, support services, and policies that foster more engaging and effective online learning experiences.

This study seeks to address the following testable hypotheses: 1) Peer interaction significantly influences students' engagement in online learning. 2) Self-efficacy significantly affects students' engagement in online learning. 3) Peer interaction and self-efficacy jointly predict levels of student engagement in online learning.

Method

This study employed a quantitative survey design to examine the relationship between peer interaction, self-efficacy, and student engagement in online learning environments. A quantitative approach was chosen for its strength in establishing patterns, relationships, and statistical generalizations across a defined population (Creswell, J. W., & Creswell, 2022). Specifically, the design was aimed at testing the direct and combined effects of the independent variables peer interaction and self-efficacy on the dependent variable, student engagement.

This approach aligns with recent studies in the field that have utilized survey-based methodologies to assess psychological and behavioral constructs in educational settings (Alqurashi, 2020; Kuo, Y.-C., Tseng, T.-H., Yang, J.-M., & Yao, 2021; Lopez, A., Robinson, T., & Lee, 2023). The structured nature of this design facilitated the collection of measurable data conducive to statistical analysis, providing insights into how these psychosocial variables influence learners' engagement in digital learning platforms.

The sample population consisted of 100 tenth-grade students from SMAN 1 Mancak, a senior high school located in Serang, Banten, Indonesia. The sample comprised approximately 63% female and 37% male students, with a mean age of 16.0 years (SD = 0,7). Information regarding socio-economic status (SES) was not specifically collected, but the school primarily serves a middle-income demographic in the Serang area. The participants were selected using a purposive sampling technique, which enabled the researchers to deliberately choose individuals who met specific criteria relevant to the research objectives.

The criteria for selection included: 1) currently enrolled as a tenth-grade student at SMAN 1 Mancak, 2) actively participating in online classes for at least 1 semesters, 3) having consistent access to digital learning platforms (e.g., Google Classroom, Zoom), and 4) having engaged in virtual collaborative tasks or discussions within their online courses. This sampling method ensured the inclusion of students who could provide relevant and reliable data concerning peer interaction, self-efficacy, and online engagement (Etikan, I., Musa, S. A., & Alkassim, 2016).

The focus on tenth-grade students was informed by their developmental stage, which typically features increasing autonomy and digital competence in learning (Utami, N. W., Widodo, A., & Tabroni, 2023). A power analysis was conducted using G*Power 3.1 to determine the minimum required sample size for detecting a medium effect size ($f^2 = 0.15$) with an alpha of 0.05 and power of 0.80 for multiple linear regression with two predictors. The analysis indicated a minimum sample size of approximately 68 participants. Thus, the collected sample of 100 students was considered sufficient to achieve adequate statistical power.

Data collection was conducted in April, 2025, approximately 5 years after the peak of the COVID-19 pandemic and the widespread transition to online learning, representing a more normalized online learning environment for the students. Prior to data collection, ethical approval was obtained from Universitas Situs Jaya Banten Informed consent was obtained from all participating students and their parents/guardians, clearly explaining the study's purpose, assurance of anonymity and confidentiality, and their right to withdraw at any time. Participation was entirely voluntary. Data collection was performed using a Likert-scale questionnaire designed to measure the three key constructs: peer interaction, self-efficacy, and student engagement in online learning.

The instrument consisted of closed-ended items rated on a 5-point scale, ranging from “strongly disagree” to “strongly agree”. The questionnaire items were developed based on validated instruments from previous research and were adapted to suit the educational context and language proficiency of Indonesian high school students. The peer interaction scale included items related to frequency and quality of communication with classmates in virtual settings (Deng, R., & Tavares, 2020; Phan, M. N., Valiente, C., & Ngu, 2021). The self-efficacy scale measured students' confidence in managing online tasks, using technology, and sustaining independent study (Irawan, A. W., Dwisona, D., & Lestari, 2020; Zhou, M., He, Q., & Brouwer, 2021).

The student engagement scale addressed behavioral, emotional, and cognitive dimensions, such as participation in discussions, emotional interest, and effort in understanding course content (Miranda, D., Gaudioso, E., & Martínez, 2020; Redmond, J., Lock, J. V., Wieman, R., & Waycott, 2020). Sample items for each scale are provided in Appendix A.

To ensure the quality of the instrument, a validity and reliability test was conducted prior to the main data collection. A pilot study involving 30 students from a similar demographic (but not included in the main sample) was conducted to refine questionnaire items and ensure clarity and comprehensibility. Feedback from the pilot study was used to make minor adjustments to the wording of several items before the final survey administration. Content validity was established through expert review involving educational researchers and online learning practitioners who evaluated the relevance and clarity of the items.

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Construct validity was verified using factor analysis to confirm that the items accurately reflected the theoretical dimensions of each construct (Yusoff, 2021). Reliability was examined through Cronbach's alpha coefficients for each subscale. All constructs demonstrated acceptable reliability, with alpha values exceeding the recommended threshold of 0.70, indicating strong internal consistency (Taber, 2018). These psychometric evaluations ensured that the instrument accurately measured the intended constructs and could be trusted for statistical inference.

The data analysis was conducted using descriptive statistics and multiple linear regression techniques. Descriptive statistics, including means, standard deviations, and frequency distributions, were used to summarize the respondents' characteristics and provide an overview of the levels of peer interaction, self-efficacy, and student engagement. This preliminary analysis offered insights into the central tendencies and variability of each variable within the sample (Aliyyah, R. R., Adawiyah, W. R., Garzia, M., Muslihudin, M., & Nurkhin, 2020; Tan, S. C., Li, J., & Koh, 2022). Missing data were not observed in the dataset**.** To address the research questions and test the study's hypotheses, multiple linear regression analysis was employed to determine the extent to which peer interaction and self-efficacy predict student engagement, both independently and jointly. This method is appropriate for examining relationships between continuous variables and for identifying the relative contribution of each predictor variable (Field, 2020). All statistical analyses were conducted using SPSS version 26, with significance levels set at $p < 0.05$.

Results

This study investigated the impact of peer interaction and self-efficacy on student engagement in online learning among tenth-grade students at SMAN 1 Mancak, Serang, Banten. The data analysis involved reliability testing using Cronbach's Alpha, descriptive statistics, and multiple linear regression analysis to determine the individual and combined effects of peer interaction and self-efficacy on students' engagement in online learning. Prior to conducting the main analysis, assumption tests were performed to ensure the appropriateness of the regression model.

The internal consistency of the research instruments was tested using Cronbach's Alpha. As shown in Table 1, the reliability coefficients for the three constructs—peer interaction, self-efficacy, and student engagement—were all above the acceptable threshold of 0.70 (Taber, 2018). The overall Cronbach's Alpha was 0.819, and the alpha based on standardized items was 0.821, indicating high internal consistency of the questionnaire items across the three variables. This suggests that the items were reliably measuring the intended constructs.

Table 1. Reliability Statistics

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.819	0.821	3

The descriptive analysis revealed the central tendency and distribution of responses for the three main variables: Peer Interaction, Self-Efficacy, and Student Engagement, each based on 100 valid responses. The mean scores were relatively high: Peer Interaction (M = 35.02, SD = 4.65), Self-Efficacy (M = 34.58, SD = 5.37), and Student Engagement (M = 34.53, SD = 5.35). The median values were closely aligned with the means, indicating a relatively normal distribution for all three variables. The ranges for each variable were substantial, with Peer Interaction ranging from 26 to 50, Self-Efficacy from 22 to 50, and Student Engagement from 18 to 49, suggesting some diversity in responses and student experiences.

These statistics suggest that most students reported moderate to high levels of peer interaction, self-efficacy, and engagement in online learning environments. However, the relatively large standard deviations (ranging from 4.65 to 5.37) and wide ranges indicate variability among students, potentially influenced by factors such as access to technology, prior experience, or individual motivation. No extreme outliers were identified that would significantly skew the distributions.

Table 2. Descriptive Statistics of Variables

Statistics				
		Peer Interaction	Self-Efficacy	Student Engagement
N	Valid	100	100	100
	Missing	0	0	0
Mean		35.02	34.58	34.53
Median		34.50	34.00	35.00
Mode		33	30	30
Std. Deviation		4.649	5.371	5.349
Variance		21.616	28.852	28.615
Range		24	28	31
Minimum		26	22	18
Maximum		50	50	49
Sum		3502	3458	3453

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Prior to conducting the multiple linear regression, assumptions were checked. Visual inspection of histograms and Q-Q plots indicated that the residuals were approximately normally distributed. A scatter plot of predicted values against residuals showed a relatively even distribution, suggesting homoscedasticity. Linearity was assessed through partial regression plots, which showed a linear relationship between the independent variables and the dependent variable. Multicollinearity was assessed using Variance Inflation Factors (VIFs), which were all below 2, indicating no significant multicollinearity issues.

To investigate the influence of peer interaction and self-efficacy on student engagement, a multiple linear regression analysis was conducted. The results are presented in Table 3 (Model Summary) and Table 4 (Coefficients).

Table 3. Model Summary

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.722[a]	0.521	0.512	3.738	0.521	52.852	2	97	0.000

The regression model produced an R value of 0.722, indicating a strong positive correlation between the predictors (peer interaction and self-efficacy) and student engagement. The R2 value of 0.521 suggests that approximately 52.1% of the variance in student engagement can be explained jointly by peer interaction and self-efficacy. This indicates a substantial explanatory power of the model. The adjusted R2 (0.512) further supports this, accounting for the number of predictors in the model and providing a more conservative estimate of the population variance explained. The F-change statistic ($F(2,97)=52.852$, $p<0.001$) indicates that the model as a whole is statistically significant and explains a significant amount of variance in student engagement.

Table 4. Coefficients

Coefficients						
Model				Standardized Coefficients	t	Sig.
				Beta		
1	(Constant)	3.775	3.041		1.241	0.217
	Peer_Interaction	0.481	0.096	0.418	4.997	0.000
	Self_Efficacy	0.402	0.083	0.404	4.826	0.000

Both independent variables demonstrate a statistically significant positive effect on student engagement:

- **Peer Interaction:** The unstandardized coefficient (B=0.481) indicates that for every one-unit increase in peer interaction, student engagement is predicted to increase by 0.481 units, assuming self-efficacy remains constant. This effect is highly significant (t=4.997, p<0.001). The 95% confidence interval for B (0.291, 0.670) suggests that the true effect of peer interaction on student engagement in the population is likely to fall within this range. The standardized beta coefficient (β=0.418) indicates a substantial unique contribution of peer interaction to the model.
- **Self-Efficacy:** The unstandardized coefficient (B=0.402) suggests that for every one-unit increase in self-efficacy, student engagement is predicted to increase by 0.402 units, assuming peer interaction remains constant. This effect is also highly significant (t=4.826, p<0.001). The 95% confidence interval for B (0.237, 0.567) provides a range for the true population effect. The standardized beta coefficient (β=0.404) indicates a significant unique contribution of self-efficacy to the model.

The standardized Beta coefficients show that Peer Interaction (β=0.418) and Self-Efficacy (β=0.404) have nearly equal relative contributions to predicting student engagement. This suggests that both social interaction and individual beliefs about one's capabilities play a comparably important role in fostering student engagement in online learning.

Discussion

This study aimed to investigate the impact of peer interaction and self-efficacy on student engagement in online learning among tenth-grade students at SMAN 1 Mancak, Serang, Banten. The findings provide compelling empirical evidence for the significant and positive influence of both peer interaction and self-efficacy on student engagement in the online learning context.

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The strong positive correlation observed between the predictors (peer interaction and self-efficacy) and student engagement (R=0.722) underscores the interconnectedness of these factors in shaping students' involvement in virtual learning environments. The substantial variance in student engagement explained by the model (R2=0.521, representing a large effect size) highlights the practical importance of considering both social and psychological aspects when designing and implementing online learning experiences. This finding aligns with existing literature that emphasizes the crucial role of psychosocial factors in online learning success (Alqurashi, 2020; Bolliger, D. U., & Martin, 2021). Our results further strengthen this understanding by demonstrating that these factors collectively account for over half of the variability in student engagement.

The significant positive effect of peer interaction on student engagement (B=0.481, p<0.001) strongly corroborates the Community of Inquiry (CoI) framework. This framework posits social presence, often manifested through peer interaction, as a key element for sustained engagement (Garrison, 2022). Our findings suggest that engaging with peers through discussions, collaborative projects, and feedback mechanisms likely fosters a sense of belonging, reduces feelings of isolation, and enhances motivation to participate actively in learning activities (Bayoumy, A. A. A., & Alsayed, 2021; Yang, F., Liu, S., Yu, Z., & Cheng, 2023). This finding is particularly salient in the context of online learning, as it addresses concerns that the absence of traditional classroom settings might limit spontaneous peer interaction and negatively impact engagement (Dhawan, 2020). The results suggest that even in online environments, when structured and facilitated appropriately, peer interactions can effectively promote student engagement, echoing previous research on the positive impact of collaboration in online settings.

Similarly, the significant positive impact of self-efficacy on student engagement (B=0.402,p<0.001) reinforces the well-established link between a learner's belief in their capabilities and their active participation in academic tasks (Irawan, A. W., Dwisona, D., & Lestari, 2020; Zhang, K., Zhao, Y., Zhou, L., & Jiang, 2021). Students who are confident in their ability to navigate online learning tools, manage their learning, and succeed academically are more likely to be behaviorally, emotionally, and cognitively engaged (Chen, P.-S. D., Lambert, A. D., & Guidry, 2023; Sun, L., Chen, J., & Zhang, 2021). This finding aligns with Bandura's social cognitive theory, which posits that self-efficacy influences motivation, effort, and persistence. Our study underscores the importance of strategies aimed at building students' confidence in their online learning abilities, such as providing clear instructions, offering opportunities for practice, and giving constructive feedback, as these are crucial for fostering engagement.

Interestingly, the standardized beta coefficients revealed that peer interaction (β=0.418) and self-efficacy (β=0.404) had almost equal relative contributions to predicting student engagement. This balance suggests that both

social connections and individual beliefs about one's capabilities are equally important drivers of engagement in online learning. This finding highlights a crucial synergy: effective online learning likely requires both a supportive social environment and confident individual learners. Educational interventions should, therefore, aim to foster both meaningful peer relationships and strong self-efficacy beliefs among students to maximize their engagement. While both are critical, neither appears to overwhelmingly dominate the other in predicting engagement in this context.

This study contributes to the existing body of literature by providing empirical evidence of the combined influence of peer interaction and self-efficacy on the multidimensional construct of student engagement (behavioral, emotional, and cognitive) in a post-pandemic online learning context. Unlike some previous studies that focused primarily on the individual effects of these variables (Kim, J., Lee, J., & Lee, 2022; Phan, M. N., & Ngu, 2021), this research demonstrates their joint predictive power, offering a more holistic understanding.

Furthermore, by conducting the study in a Southeast Asian educational setting, specifically among tenth-grade students at SMAN 1 Mancak, Serang, Banten, it adds valuable cultural and contextual depth to the field, addressing the noted gap in research from diverse educational contexts (Lee, J., & Jung, 2022; Nugroho, A., Sutama, S., Prayitno, H. J., & Nurhadi, 2023). The findings from this study, conducted after the initial emergency phase of online learning, offer timely insights into how these dynamics play out in a more normalized digital learning environment (Han, S., Shakhsi, S., & Jung, 2022; Trisnawati, M., Suharsono, N., & Nurhayati, 2024), where students may have become more accustomed to online modalities.

The implications of these findings for educational practice are significant and actionable. Educators should prioritize the design of online learning environments that actively facilitate meaningful and effective peer interactions. This can be achieved through specific strategies such as the incorporation of well-structured collaborative activities, the use of discussion forums with clear guidelines for interaction and active moderation, implementation of peer feedback opportunities, and the strategic leveraging of online tools that support synchronous and asynchronous communication and teamwork.

Additionally, instructional strategies should consistently focus on enhancing students' self-efficacy. This can be done by providing clear scaffolding for complex tasks, breaking down challenging assignments into more manageable steps, offering specific and positive reinforcement for effort and progress, and promoting a growth mindset that encourages resilience and learning from mistakes. For policymakers, these findings suggest the importance of investing in resources and training for educators to effectively implement these strategies, ensuring that online learning platforms are not merely content delivery systems but also foster robust social and individual growth.

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While this study provides valuable insights, it is important to acknowledge its limitations. The primary limitation stems from the cross-sectional nature of the quantitative survey design, which, while identifying significant relationships, precludes the establishment of definitive causal inferences. We can conclude that peer interaction and self-efficacy are strong predictors of engagement, but not that they are the sole causes. Future research could benefit from employing qualitative or mixed-methods approaches (e.g., interviews, focus groups, observational studies) to explore the nuances of students' experiences and the underlying mechanisms through which peer interaction and self-efficacy influence engagement in more detail.

Additionally, the sample was drawn from a single school in Indonesia, which may limit the generalizability of the findings to other cultural or educational contexts with different technological infrastructures, pedagogical approaches, or student demographics. Further research involving larger and more diverse samples across various regions and educational levels is needed to validate these findings across different populations and settings. Longitudinal studies could also provide invaluable insights into how peer interaction, self-efficacy, and engagement evolve over the course of an online learning program, tracking changes and reciprocal influences over time.

Furthermore, exploring the role of moderating or mediating variables, such as instructor presence, course design quality, or access to technology, could provide a more comprehensive understanding of student engagement in online learning.

In conclusion, this study underscores the critical roles of peer interaction and self-efficacy in fostering student engagement in online learning. By highlighting the independent and combined positive effects of these factors, the findings offer robust empirical evidence and practical guidance for educators and instructional designers seeking to create more engaging and effective online learning experiences. Investing strategically in interventions that promote social connections among learners and build their confidence in their online learning abilities is not just beneficial but essential for maximizing student success in the rapidly evolving landscape of digital education.

Conclusion

This study aimed to investigate the impact of peer interaction and self-efficacy on student engagement in online learning environments among tenth-grade students at SMAN 1 Mancak, Serang, Banten. The findings strongly support the hypothesized relationships, demonstrating that both peer interaction and self-efficacy significantly influence student engagement.

The reliability analysis confirmed the internal consistency of the measurement instruments, with all constructs exceeding the acceptable Cronbach's Alpha threshold. Descriptive statistics indicated that students generally reported moderate to high levels of peer interaction, self-efficacy, and student

engagement, although there was notable variability across the sample.

The multiple linear regression analysis revealed a robust model, explaining 52.1% of the variance in student engagement. Both peer interaction and self-efficacy emerged as significant positive predictors of student engagement. Specifically, an increase in either peer interaction or self-efficacy was associated with a corresponding increase in student engagement. The standardized beta coefficients indicated that both factors contribute almost equally to predicting student engagement in online learning.

These results underscore the critical roles that both social dynamics and individual psychological attributes play in fostering student engagement in digital learning settings. The significant impact of peer interaction highlights the importance of creating opportunities for meaningful learner-to-learner communication and collaboration in online courses, as this fosters a sense of community and shared knowledge construction. Similarly, the strong influence of self-efficacy emphasizes the necessity of cultivating students' confidence in their ability to navigate online tools, manage their learning independently, and overcome challenges.

The findings of this study have important implications for instructional design, support services, and policy development in online education, particularly in post-pandemic contexts. Educators and institutions should prioritize strategies that enhance both peer interaction (e.g., through collaborative projects, online discussions, and group activities) and self-efficacy (e.g., through clear instructions, scaffolding, timely feedback, and fostering a growth mindset) to optimize student engagement and, consequently, academic success in online learning environments.

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