The Contribution of Smartphone Learning Models on Student Academic Performance: The Role of Mediating Effects

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***Abstract*—Education that reflects the fast growth of technology must be considerably enhanced, for instance, through learning media. Charles Prosser played a crucial role in engineering education by establishing standards for the field. In line with this legacy, the current study aims to examine the impact of focused immersion, digital literacy, and learning motivation on learning methods and the academic success of engineering students. A quantitative method with a cross-sectional survey design was used to engage 420 students from the Faculty of Engineering at an Indonesian institution. Based on the data analysis, the structural equation model (SEM) was considered, and the results showed that focused immersion (p = 0.000), digital literacy (p = 0.014), and learning motivation (p = 0.000) served as mediators between learning methods and academic achievement in Prosser's theory, as can be seen from the significant value of p<0.05. Ultimately, the results of this research contribute to understanding the important role of focused immersion, digital literacy, and learning motivation in improving students' academic performance in engineering education.**

***Keywords*—focused immersion, digital literacy, learning motivation, learning strategies, student academic performance**

I. Introduction

Nowadays, students encounter education with a growing amount of integration from smartphone technology [1, 2]. The propensity of students to spend a lot of time on smartphones can have a positive influence on the design of smartphone-based applications. The integration of innovative teaching and training tools has the potential to improve not only overall academic achievement for learners but also the quality of their understanding [3], access to learning opportunities, student ability to acquire skills through the use of real-world situations, and overall progress in learning. The process of ensuring that pupils grasp the significance of all they have learned must be monitored [4].

Engineering education is a complex and multifaceted process influenced by various internal and environmental factors that impact student achievement. Furthermore, the process of engineering education requires students to possess strong cognitive, problem-solving, and information-processing skills [5]. The importance of student's academic performance in engineering education mirrors both the quality of the education system and their readiness for future challenges in their careers. Robust academic performance is characterized by a solid understanding of key concepts, critical thinking abilities, and the capability to apply information to real-world issues [6].

In addition, Charles Prosser played a crucial role in structuring and coordinating the engineering education system. Specifically, Prosser aimed to address challenges in engineering education through the development of curricula, enhancement of practical training, and improvement of collaboration between engineering education institutions and industry. In this context, the primary mission was to make education more relevant and prepare graduates to handle contemporary issues. After completing education, student needs to decide whether to pursue advanced studies. However, career paths are not immediately chosen after completing education. Additionally, the introduction should articulate the relevance and significance of study questions in the field [7].

Obstacles in engineering education keep evolving, thereby requiring continual efforts to be consistent with the demands of today's economy and workforce. Prosser's Sixteen Theorems provide a strong foundation for bridging the gap between education, business, and employment. Specifically, industry standards and work practices show that effective vocational training should be in line with the job, using the same processes, tools, and machinery [8].

Subsequently, to achieve the desired result, there are some clarifying questions, such as: 1) what are the prospects for engineering graduates? 2) what skills are needed, and 3) what kind of education will be received? The challenges facing engineering graduates are becoming increasingly intricate and diverse [5, 6]. While engineering education has progressed by enhancing problem-solving abilities, graduates need to also possess a strong desire to learn and the ability to adapt and continuously improve their skills [7, 8]. Investigation of skills and learning mechanisms facilitating their development should guide future enhancements in engineering education [9].

According to the Posser context, engineering student need to excel in a skill relevant to their future industrial environment. In this context, student is expected to acquire skills in line with their prospective industry. The tension between theory and practice is commonplace in engineering education, particularly within companies. While refining skills of student in a discipline related to their future industry is beneficial, those with strong multitasking abilities have enhanced employment prospects. Competence can be improved through various methods, including optimizing learning process [10].

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Focused immersion is attainable through deep and concentrated learning experiences on specific topics or technical skills [11]. The purpose of focused immersion in engineering education is to provide student with a detailed and comprehensive learning experience, enabling a better understanding of technical concepts and the development of skills pertinent to their engineering profession [12].

Methods for enhancing competence include offering industry internships, leveraging technology, and fostering interest of student in learning [13]. Digital literacy refers to an individual's effective use of digital technology and media, including the ability to find, evaluate, comprehend, and communicate information online [14]. Student with strong digital literacy can leverage technology to access more knowledge, explore deeper, and communicate in innovative ways [15]. Moreover, digital technology can be used to incorporate interactive learning methods, such as game-based learning, simulations, or personalized online learning platforms [11, 13].

Engineering education studies often require a thorough understanding of scientific concepts, practical application of technical skills, and a commitment to staying abreast of rapid technological advancements. Learning motivation is crucial in engineering education to support academic and professional success of student. This phenomenon helps to promote a lifelong learning spirit and a strong desire to comprehend and apply knowledge for technological and societal development [16].

The educational context consists of an effective and sustained learning process where student acquire knowledge, abilities, and understanding [17]. Effective learning strategies are important in vocational education for producing graduates who are competent and prepared to face workplace challenges. The use of effective and comprehensive learning methods will facilitate the development of graduates with competency, competitiveness, and readiness to confront industry and professional challenges. When skills training is executed correctly, student can address various technical challenges and make significant contributions to technology and innovation advancement.

Various methods, including tests, exams, projects, presentations, and other assessments, are commonly used to evaluate student academic performance [14, 17]. Academic Performance comprises academic accomplishments and achievements throughout academic journey [15]. For graduates in vocational education, academic performance plays a crucial role in determining educational attainment and readiness for entering the workforce or pursuing higher education. Attaining high academic achievements is essential to develop a thorough understanding of engineering principles and the ability to apply them in real-world situations [18, 19]. Therefore, institutions and faculties need to actively encourage and support student in order to become successful and competent vocational education graduates [20].

The current exploration investigates the impact of focused immersion, digital literacy, and learning motivation on academic achievement in engineering education [15]. Limited studies comprehensively examine the simultaneous associations between these variables, hence this study aims to provide empirical data on the effects of learning styles on academic achievement in engineering education. In addition, the study aims to describe the direct, indirect, and mediating effects of focused immersion, digital literacy, and motivation on learning styles and academic achievement in engineering education in the framework of Prosser's theory.

II. Materials and Methods

Charles Allen Prosser (1914) stated the theory of functional and quality technical and vocational education for the acquisition of skills and the desire for economic and technological growth in a country. In 1925, Prosser summarized his philosophy into sixteen "theorems." Charles Prosser is a philosopher who views the philosophy of vocational education as essentialism in accordance with his theories. This theory will be studied and explored in this research to see and prove the relevance of Prosser's theory in current engineering education. Fig 1 will display the design of the Android mobile learning application.

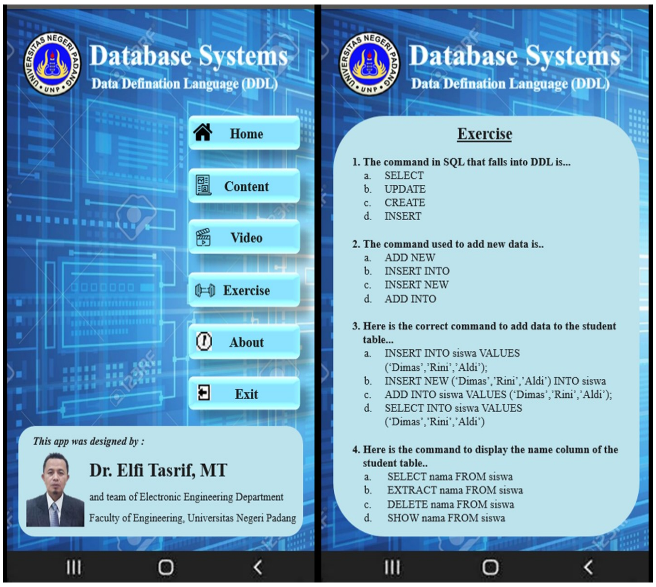

Fig. 1. Mobile Android learning application.

After the design of the application (Fig. 1) is completed, it will be utilized by the students to facilitate the progress of this study. The study comprised 420 students from the Faculty of Engineering at Universitas Negeri Padang in Indonesia. It was crucial to recognize that the sample comprised specific individuals and did not represent the entire population. The sample was chosen using non-probability sampling through a data-based census method with saturation strategies, as opposed to random selection. Participants in this research have used Android-based learning applications that were intended to aid the learning process. These participants were recruited using internet media, and they subsequently completed a pre-prepared web-based questionnaire.

Surveys were then distributed to collect information on Learning Motivation, Focused Immersion, Student Academic Performance, and Digital Literacy. Surveys proved effective in collecting data for investigating variables and anticipating participant responses.

To conduct the mediation effect test, the complementary mediation test procedure was used. This consisted of studying the direct and indirect effects and testing statistical significance, while avoiding subjective assessments. Technical abbreviations were explained during the first usage, and the writing was consistent with conventional academic structure with consistently applied citations and formal language variants. The demographic characteristics of the 420 respondents were shown in Table 1.

Table 1. Characterization respondents

Sample Characterization		Frequency	Percent
Gender	Male	278	66.2
	Female	142	33.8
	Total	420	100
Age	<21 years old	285	67.9
	21-23 years old	128	30.5
	>23 years old	7	1.7
	Total	420	100
Student ID Number	2020	178	42.4
	2019	143	34.0
	2018	82	19.5
	2017	17	4
	Total	420	100
Major	Electronic Engineering	97	23.1
	Electrical Engineering	68	16.2
	Mechanical Engineering	58	13.8
	Automotive Engineering	60	14.3
	Civil Engineering	60	14.3
	Mining Engineering	77	18.3
	Total	420	100

Table 1 showed gender variations, with males (66%) outnumbering females. Regarding age, those above 21 year had the highest participation (61.9%). In terms of the registration year, student in 2020 had the highest proportion of participation (42%), while student in 2017 had the lowest (4%). Electronics engineering majors (23.1%) constituted the majority of participants.

The saturated sample method was used to determine the test, requiring sampling all members of the population. The sample was selected through non-probability sampling, showing it was not randomly selected. The sample did not have equal access to all aspects of the population.

III. Result and Discussion

The data collected from this investigation were as followed:

A. *Measurement Model Assessment*

The measurement evaluated the correlation between latent variables and the respective statements. Additionally, assessment model measurement showed an association between each of the indicators and its corresponding variable, known as latent, with the following tests conducted:

1) *Convergent validity*

Convergent validity testing analyzed the influence of certain variable measurement items on bending effects [21]. In this test, four aspects had to be considered, namely 1) the item was valid when its outer loading was greater than 0.7, 2) the data was reliable when Cronbach's alpha exceeded 0.7, 3) the required composite reliability value had to be above 0.7, and 4) the required average extracted variance (AVE) value had to be above 0.5.

All statement items on learning Motivation, Focused Immersion, Student Academic Performance, and Digital Literacy variables with an outer loading value > 0.7 were considered valid, while those with a value < 0.7 were withdrawn from the model. Table 2 showed that e-learning AVE, Focused Immersion, Student Academic Performance, and Digital Literacy had values > 0.5. E-learning AVE had a loading value of 0.75, Focused Immersion had a value of 0.698, Student Academic Performance had a value of 0.765, Digital Literacy had a value of 0.623, and Learning Strategies had a value of 0.714.

Table 2. Internal consistency reliability dan convergent validity results

Predictor	Item	Outer Loading >0.7	Cronbach Alpha	Composite Reliability	AVE > 0.5
Learning Motivation	LM1	0.846	0.933	0.947	0.75
	LM2	0.869			
	LM3	0.866			
	LM4	0.891			
	LM5	0.846			
	LM6	0.877			
Focused Immersion	FI1	0.845	0.784	0.874	0.698
	FI2	0.845			
	FI3	0.816			
Student Academic Performance	SAP1	0.893	0.846	0.907	0.765
	SAP2	0.824			
	SAP3	0.905			
Digital Literacy	DL1	0.815	0.899	0.920	0.623
	DL2	0.817			
	DL3	0.775			
	DL4	0.745			
	DL6	0.776			
	DL7	0.791			
	DL8	0.802			
Learning Srategies	LS1	0.846	0.919	0.937	0.714
	LS2	0.869			
	LS3	0.866			
	LS4	0.891			
	LS5	0.846			
	LS6	0.877			

The latent variables classified the measurement variance, hence, composite reliability values from Table 2 showed that Focused Immersion, Student Academic Performance, and Digital Literacy all exceeded 0.7. The Cronbach's alpha value for Learning Motivation was 0.933, with values of 0.784, 0.864, and 0.899 for Focused Immersion, Student Academic Performance, and Digital Literacy, respectively, all surpassing 0.7. Therefore, measuring each aspect of Learning Motivation, Focused Immersion, Student Academic Performance, and Digital Literacy provided reliable and consistent data.

2) Discriminant validity

The Fornell-Larcker criterion examined the distinguishability of a construct from others [22]. For example, when a hidden variable shared variance with the underlying indicator but outperformed others, the variable had a distinctive value. This meant that the unique value was observed when the variance of a variable, indicator, or item exceeded the variance of the latent variable when compared to others.

Table 3 showed that all correlation values of the Fornell-Lacker criterion for each variable satisfied the discriminant validity test requirements. Several numbers with values close to 0.9 were considered satisfactory and approved [23].

The test result in Table 4 showed that all variables had a Heterotrait-Monotrait Ratio of 0.90, showing valid (unique) discriminant validity. Furthermore, the variables/constructs under consideration were diametrically opposed to one another. Henseler established a measuring standard with a 0.90 value as the upper limit of the ratio and declared that a ratio distribution with a value less than 0.90 was considered a legitimate discriminant [21].

Table 3. Fornell Larcker criterion results

Predictor	Digital Literacy	Focused Immersion	Learning Motivation	Learning Strategies	Student Academic Performance
Digital Literacy	0.789				
Focused Immersion	0.536	0.835			
Learning Motivation	0.545	0.501	0.866		
Learning Strategies	0.701	0.529	0.734	0.845	
Student Academic Performance	0.560	0.597	0.780	0.678	0.875

Table 4. Heterotrait Monotrait ratio (HTMT) results

Predictor	Digital Literacy	Focused Immersion	Learning Motivation	Learning Strategies
Digital Literacy				
Focused Immersion	0.635			
Learning Motivation	0.587	0.579		
Learning Strategies	0.765	0.622	0.789	
Student Academic Performance	0.640	0.726	0.877	0.768

B. Structural Model Assessment

The statistical method used to analyze and explain the relationship between latent variables (which are not measured directly) and measurable variables (which can be measured directly) in a model is often known as SEM analysis. This analysis allows researchers to test hypotheses about the relationships between variables and test complex conceptual models involving many variables, both independent and dependent [22].

The link between latent and measurable variables is measured using a variety of approaches in SEM analysis, including path analysis, factor analysis, and regression analysis. SEM analysis results can provide comprehensive knowledge of the structure and causality of a conceptual model while also allowing for more complex hypothesis testing than typical statistical methods [22].

SMA predicted the causation of latent variables. The R and Q square tests in SEM PLS were used to assess the process at this point. In addition, bootstrapping was used to conduct a significance test for predicting the existence of a causal relationship. Furthermore, PLS study question testing adopted a non-parametric bootstrapping perspective to assess the importance of the coefficients rather than relying on normally distributed data.

1) R-square dan Q-square

R-squared assesses how much variance in endogenous variables (measurement variables) can be explained by exogenous factors (latent variables) in the model. R-square shows how well the suggested model matches the observed data. In general, the R value goes from 0 to 1, with a greater number indicating that the model fits the data better [22].

Meanwhile, Q-square is an extra metric that goes from $-\infty$ to 1, and a greater number suggests a more accurate forecast. Q-square is an out-of-sample predictive metric that shows how well a SEM model can predict the values of endogenous variables that were not utilized in model construction [22].

In evaluating latent variables, the R-squared test assessed the extent to which exogenous variables impacted endogenous variables. In the structural model, a value of 0.26 or above was regarded as a significant requirement for establishing the strong effect of exogenous factors on endogenous variables. Moreover, a score range of 0.13-0.25 showed considerable digital literacy and a value range of 0.02-0.12 indicated a minor effect [24].

Q-square (predictive relevance) predicted the model's measurement value and estimated the parameters. A number greater than zero implied that the model was predictively relevant, while a number less than zero showed that the model was not predictive. When the value achieved was 0.35 or above, the structural model's predictive relevance was considered good. However, when the value fell between 0.15 and 0.35, it was considered medium [25].

Table 5. R square and Q square

Variable	R Square	Q Square
Digital Literacy	0.491	0.301
Focused Immersion	0.280	0.190
Learning Motivation	0.539	0.400
Student Academic Performance	0.672	0.508

Table 5 showed the R square value of Digital Literacy, which was 0.491. Learning Motivation, Focused Immersion, and Student Academic Performance collectively accounted for 67.2% of the impact on Digital Literacy, indicating its high quality. Moreover, the variable had a Q square value of 0.400, suggesting that Learning Motivation, Focused Immersion, and Student Academic Performance could accurately predict Digital Literacy. The R squared score for Student Academic Performance variable, 0.672, implied that the influence of Learning Motivation and Focused Immersion on Student Academic Performance was substantial, at 67.2%.

The Q square value of 0.508 for Student Academic Performance variable showed the ability of Learning Motivation and Focused Immersion to reliably predict Student Academic Performance. Meanwhile, Focused Immersion variable yielded an R square of 0.280, showing that Learning Motivation had a 28% predictive effect on Focused Immersion. Finally, the Q square value for Focused Immersion variable was 0.190, showing that e-learning had a medium capacity to predict Focused Immersion.

2) Path analysis and study questions testing

Study questions were addressed through data analysis using the bootstrapping method [26]. A T statistic value exceeding 1.96 and a significant value less than 0.05 showed the presence of exogenous variables influencing the endogenous and vice versa [27]. The T statistic values were presented in Fig. 2.

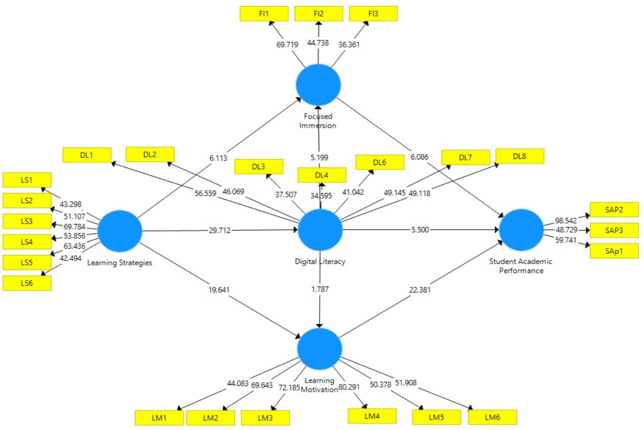

Fig. 2. Model Calculation Results with T values (Smart PLS 3).

Fig 2 displays the T-statistic values for the analyzed model. In this analysis, a T-statistic value exceeding 1.96 indicates a significant influence of exogenous variables (independent variables) on endogenous variables (dependent variables), or vice versa. The T-statistic values are used to assess the strength and significance of the relationships between the variables in the model. A T-value greater than 1.96 suggests a significant impact of exogenous variables on endogenous variables. Next, Fig. 3 will display the results of the p-value.

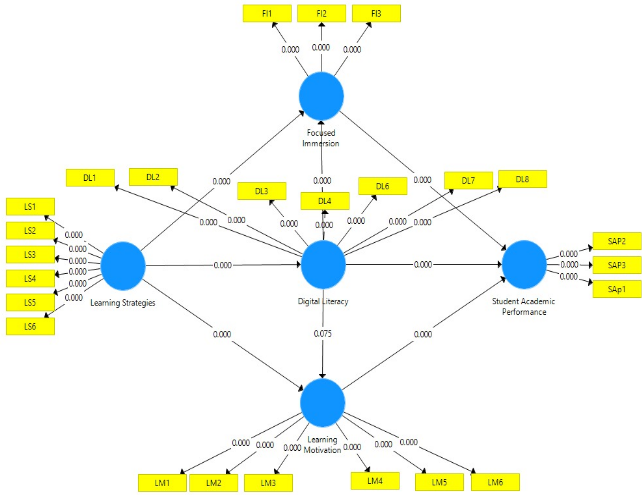

Fig. 3. Model Calculation Results with P-Value (SmartPLS 3).

Fig 3 presents the p-values for the analyzed model. The p-value is used to measure the statistical significance of the relationships between variables. In this study, a p-value less than 0.05 indicates that the relationship between variables is significant. Therefore, when the p-value < 0.05 and the T-statistic > 1.96, it demonstrates that there is a significant influence of exogenous variables on endogenous variables and vice versa.

Table 6. Results of the measurement model

Path Analysis	**Original Sample (O)**	**T Statistics**	**P Values**
Digital Literacy -> Student Academic Performance	0.101	2.465	0.014
Focused Immersion -> Student Academic Performance	0.240	5.127	0.000
Learning Motivation -> Student Academic Performance	0.605	15.163	0.000
Learning Strategies -> Digital Literacy	0.701	19.754	0.000
Learning Strategies -> Focused Immersion	0.529	11.037	0.000
Learning Strategies -> Learning Motivation	0.734	19.678	0.000
Learning Strategies -> Digital Literacy-> Student Academic Performance	0.642	18.691	0.000
Learning Strategies -> Focused Immersion-> Student Academic Performance	0.642	18.691	0.000
Learning Strategies -> Learning Motivation-> Student Academic Performance	0.642	18.691	0.000

T-statistic value indicated the route significance between variables in the structural model, as shown by the results of the test in Table 6. T-statistics result greater than 1.96 (two-tailed, $\alpha = 0.05$) showed that all analyzed independent factors had a substantial influence on the dependent variables. With an original sample value of 0.101, a statistical T value of 2.465 > 1.96, and a P-value of 0.014 < 0.05, Table 6 showed that digital literacy variable had a significant influence on student academic performance. This showed that the influence of digital literacy was significant and beneficial.

The outcomes of the path analysis of Focused Immersion on Academic Performance variable showed a sample value of 0.240, signifying a positive influence. Additionally, the statistical T value was 5.127 > 1.96, and the P-value was 0.000, showing that attention immersion had a significant impact on student academic performance. Similarly, with an initial sample value of 0.605, learning motivation variable showed a positive directional impact. Learning motivation had a substantial influence on student academic achievement, as showed by a T value of 15.163 > 1.96 and a P value of 0.000, according to statistical analysis.

The study presented the results on the mediation among focused immersion, digital literacy, and learning motivation within the framework of Charles Prosser's theory. The indirect effect was complete, specific, and significant at the 95% confidence interval, showing that the predictor variable influenced the criterion variable through the mediator. Path analysis results showed a direct or indirect impact of the mediating variable on the impact variable, contributing to the improvement of the teaching and learning process in engineering and vocational education.

The use of learning models on smartphones is becoming increasingly popular in the field of education, particularly as mobile technology becomes more prominent in daily life. In this research focused immersion refers to a student's level of focus and involvement when using a smartphone for educational reasons. This may be modified by variables such as learning program design, content relevancy, and user interface. Digital literacy refers to the abilities and competencies required to properly explore and use digital technologies, particularly smartphones, for educational purposes. This includes skills like information literacy, media literacy, and technical competency. Learning motivation refers to how much students are motivated to participate in learning activities, and it may be impacted by both inner and external elements such as interest and curiosity.

Based on the above description, it could be summarized that learning motivation correlated with focused immersion. According to the results of the path analysis test, learning motivation variable indirectly influenced digital literacy through student academic accomplishment variable. Therefore, the characteristics of student academic achievement could help moderate the effect of learning motivation on digital literacy. These outcomes were in line with previous explorations [28] on how these variables interacted to influence learning process [29].

Through focused immersion, learning motivation had a significant indirect impact on digital literacy and the potential to moderate the effect of learning motivation on digital literacy factors. Focused immersion variable could mediate an indirect effect on student academic progress. Typically, both immersion and student academic achievement variables could effectively mediate the indirect effect of learning motivation on digital literacy variables.

Previous investigations described the significance of focused immersion in learning strategies, enhancing the effectiveness and efficiency of learning [12]. Focused immersion was also advantageous for digital literacy, as active participation and immersion in content motivated and engaged student in learning process [30–32]. Motivation of student to learn was increased when engaged in compelling and critical tasks [33].

Individuals were more motivated to continue learning and achieve objectives when they considered what was learned to be valuable and purposeful. Each person had a unique learning style, and adopting learning strategies suited to specific needs and preferences could result in superior outcomes [33]. To enhance learning outcomes and achieve a deeper understanding, focused immersion should be integrated into a broader learning method. Immersion in a specific topic could substantially impact one's learning strategies and academic success.

Effective engineering education is needed to develop multitasking skills in student [34]. Such skills were highly valuable in the complex and dynamic workplace, where the ability to perform multiple tasks simultaneously was essential. These abilities were increasingly crucial in today's demanding workplace [35]. Student would be better prepared to handle workplace demands with engineering education that focused on developing these skills.

Understanding the intricate interplay between these parameters can help academics build and execute successful smartphone-based learning models that improve student engagement and learning results. These findings can help shape educational interventions and policies targeted at maximizing the potential of mobile technology to improve students' learning experiences in a variety of educational contexts, particularly in engineering education.

IV. Conclusion

In conclusion, this study showed the influence of focused immersion, digital literacy, and student academic performance in the mediating learning strategies in the framework of Prosser's theory. Additionally, the results held relevance for methods in engineering and vocational education aiming to enhance learning process through both learning strategies and student academic performance. Essential components included actively engaging student in learning process and integrating real-world context through industry practice or internships. It was crucial to ensure that student acquired skills required for future job requirements. In improving academic performance of engineering student, offering assistance and support to student facing academic challenges played a crucial role. Consequently, the engineering and vocational education in Indonesia showed the capability to produce graduates well-prepared to excel in various fields.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

H.K.I. and R.F. conducted data collection; A.M. and A.H. performed statistical analysis; E.T., M.A., and H.H. interpreted the results and prepared the manuscript; E.T. supervised and designed the study; and E.T., M.A., and H.H. reviewed the paper critically. All authors have read and approved the published version of the manuscript.

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REFERENCES

[1] M. Anshari, M. N. Almunawar, M. Shahrill, D. K. Wicaksono, and M. Huda, "Smartphones usage in the classrooms: Learning aid or interference?," *Educ. Inf. Technol.*, vol. 22, no. 6, pp. 3063–3079, 2017, doi: 10.1007/s10639-017-9572-7.

[2] D. T. P. Yanto *et al.*, "Android-based courseware as an educational technology innovation for electrical circuit course: An effectiveness study," *Int. J. Inf. Educ. Technol.*, vol. 13, no. 12, pp. 1835–1843, 2023, doi: 10.18178/ijiet.2023.13.12.1996.

[3] M. Ramzan, Z. K. Javaid, and M. Fatima, "Empowering ESL students: Harnessing the potential of social media to enhance academic motivation in higher education," *Glob. Digit. Print Media Rev.*, vol. VI, no. II, pp. 224–237, 2023, doi: 10.31703/gdpmr.2023(vi-ii).15.

[4] E. Park, D. Ifenthaler, and R. B. Clariana, "Adaptive or adapted to: Sequence and reflexive thematic analysis to understand learners' self-regulated learning in an adaptive learning analytics dashboard," *Br. J. Educ. Technol.*, vol. 54, no. 1, pp. 98–125, 2023, doi: 10.1111/bjet.13287.

[5] C. Alalouch, "Cognitive styles, gender, and student academic performance in engineering education," *Educ. Sci.*, vol. 11, no. 9, p. 502, Sep. 2021, doi: 10.3390/educsci11090502.

[6] S. F. Rivas, C. Saiz, and L. S. Almeida, "The role of critical thinking in predicting and improving academic performance," *Sustainability*, vol. 15, no. 2, p. 1527, Jan. 2023, doi: 10.3390/su15021527.

[7] H. Hidayat, B. Y. Tamin, S. Herawati, Z. Ardi, and A. P. Muji, "The contribution of internal locus of control and self-concept to career maturity in engineering education," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 10, no. 6, pp. 2282–2289, Dec. 2020, doi: 10.18517/ijaseit.10.6.11698.

[8] B. Sichombe, "Tracer Study of 2017-2019 NAMCOL TVET Graduates," *J. Learn. Dev.*, vol. 9, no. 3, pp. 545–562, Nov. 2022, doi: 10.56059/jl4d.v9i3.651.

[9] C. Udeozor, R. Toyoda, F. Russo Abegão, and J. Glassey, "Digital games in engineering education: systematic review and future trends," *Eur. J. Eng. Educ.*, vol. 48, no. 2, pp. 321–339, Mar. 2023, doi: 10.1080/03043797.2022.2093168.

[10] E. Ernawati, "Fashion design education students' ability to create fashion patterns: Investigating the effect of antecedent factors," *JPPI (Jurnal Penelit. Pendidik. Indones.*, vol. 8, no. 2, p. 312, 2022, doi: 10.29210/020221733.

[11] L. Sun, M. Kangas, H. Ruokamo, and S. Siklander, "A systematic literature review of teacher scaffolding in game-based learning in primary education," *Educ. Res. Rev.*, vol. 40, p. 100546, Aug. 2023, doi: 10.1016/j.edurev.2023.100546.

[12] A. Marougkas, C. Troussas, A. Krouska, and C. Sgouropoulou, "Virtual reality in education: A review of learning theories, approaches and methodologies for the last decade," *Electron.*, vol. 12, no. 13, p. 2832, Jun. 2023, doi: 10.3390/electronics12132832.

[13] F. Dahalan, N. Alias, and M. S. N. Shaharom, "Gamification and game based learning for vocational education and training: A systematic literature review," *Educ. Inf. Technol.*, pp. 1–39, Jan. 2023, doi: 10.1007/s10639-022-11548-w.

[14] E. Cifrian, A. Andrés, B. Galán, and J. R. Viguri, "Integration of different assessment approaches: Application to a project-based learning engineering course," *Educ. Chem. Eng.*, vol. 31, pp. 62–75, 2020, doi: 10.1016/j.ece.2020.04.006.

[15] J. A. Heissel, C. Persico, and D. Simon, "Does pollution drive achievement?: (Inline image) the effect of traffic pollution on academic performance," *J. Hum. Resour.*, vol. 57, no. 3, pp. 747–776, 2022, doi: 10.3368/jhr.57.3.1218-9903R2.

[16] W. S. D. Chun, S. H. T. Yau, C. Y. Leung, H. H. H. Tang, and H. W. Hui, "The missing link of secondary STEM education in Hong Kong: Transdisciplinary integration of revitalizing vocational and professional education and training," *Lecture Notes in Educational Technology*, Springer, 2023, pp. 169–197. doi: 10.1007/978-981-19-9315-2_10.

[17] C. Woods *et al.*, "Evidence for commonly used teaching, learning and assessment methods in contact lens clinical skills education," *Contact Lens Anterior Eye*, vol. 46, no. 2, p. 101821, 2023, doi: 10.1016/j.clae.2023.101821.

[18] A. Irfansyah, Suparji, B. Suprianto, C. Kuntadi, and H. Sudarmaji, "Factors that affect the quality of vocational education graduates in the 4.0 Era: Job readiness, skills and digital services," *Dinasti Int. J. Educ. Manag. Soc. Sci.*, vol. 4, no. 4, pp. 485–496, 2023, doi: 10.31933/dijemss.v4i4.1734.

[19] O. K. Kilag, J. Miñoza, E. Comighud, C. Amontos, M. Damos, and C. F. Abendan, "Empowering teachers: Integrating technology into livelihood education for a digital future," *Excell. Int. Multi-disciplinary J. Educ.*, vol. 1, no. 1, pp. 30–41, 2023.

[20] G. Barboutidis and E. Stiakakis, "Identifying the factors to enhance digital competence of students at vocational training institutes," *Technol. Knowl. Learn.*, vol. 28, no. 2, pp. 613–650, Jun. 2023, doi: 10.1007/s10758-023-09641-1.

[21] J. Henseler, C. M. Ringle, and M. Sarstedt, "A new criterion for assessing discriminant validity in variance-based structural equation modeling," *J. Acad. Mark. Sci.*, vol. 43, no. 1, pp. 115–135, Jan. 2015, doi: 10.1007/s11747-014-0403-8.

[22] C. Fornell and D. F. Larcker, "Evaluating structural equation models with unobservable variables and measurement error," *J. Mark. Res.*, vol. 18, no. 1, p. 39, Feb. 1981, doi: 10.2307/3151312.

[23] I. Masudin, A. Ramadhani, D. P. Restuputri, and I. Amallynda, "The effect of traceability system and managerial initiative on Indonesian food cold chain performance: A Covid-19 pandemic perspective," *Glob. J. Flex. Syst. Manag.*, vol. 22, no. 4, pp. 331–356, 2021, doi: 10.1007/s40171-021-00281-x.

[24] D. Riyanto and N. Widyaningsih, "Public transportation user movement analysis of passenger satisfaction with SEM PLS method at the tangerang selatan city bus terminal," *Int. J. Res. Rev.*, vol. 9, no. 7, pp. 733–740, Jul. 2022, doi: 10.52403/ijrr.20220777.

[25] M. Irfan and F. Ramlie, "Analysis of parameters which affects prediction of energy consumption in buildings using Partial Least Square (PLS) approach," *J. Adv. Res. Appl. Sci. Eng. Technol.*, vol. 25, no. 1, pp. 61–68, Dec. 2021, doi: 10.37934/araset.25.1.6168.

[26] J. M. Becker, J. H. Cheah, R. Gholamzade, C. M. Ringle, and M. Sarstedt, "PLS-SEM's most wanted guidance," *Int. J. Contemp. Hosp. Manag.*, vol. 35, no. 1, pp. 321–346, Jan. 2023, doi: 10.1108/IJCHM-04-2022-0474.

[27] G. A. Putri, A. K. Widagdo, and D. Setiawan, "Analysis of financial technology acceptance of peer to peer lending (P2P lending) using extended technology acceptance model (TAM)," *J. Open Innov. Technol. Mark. Complex.*, vol. 9, no. 1, p. 100027, 2023, doi: 10.1016/j.joitmc.2023.100027.

[28] E. Jang, Y. S. Seo, and J. Brutt-Griffler, "Building academic resilience in literacy: Digital reading practices and motivational and cognitive engagement," *Read. Res. Q.*, vol. 58, no. 1, pp. 160–176, 2023, doi: 10.1002/rrq.486.

[29] B. Le, G. A. Lawrie, and J. T. H. Wang, "Student self-perception on digital literacy in STEM blended learning environments," *J. Sci. Educ. Technol.*, vol. 31, no. 3, pp. 303–321, 2022, doi: 10.1007/s10956-022-09956-1.

[30] C. Lazou and A. Tsinakos, "Critical immersive-triggered literacy as a key component for inclusive digital education," *Educ. Sci.*, vol. 13, no. 7, p. 696, 2023, doi: 10.3390/educsci13070696.

[31] M. A. M. AlGerafi, Y. Zhou, M. Oubibi, and T. T. Wijaya, "Unlocking the potential: A comprehensive evaluation of augmented reality and virtual reality in education," *electron.*, vol. 12, no. 18, p. 3953, 2023, doi: 10.3390/electronics12183953.

[32] J. Kim, K. Kim, and W. Kim, "Impact of immersive virtual reality content using 360-degree videos in undergraduate education," *IEEE Trans. Learn. Technol.*, vol. 15, no. 1, pp. 137–149, 2022, doi: 10.1109/TLT.2022.3157250.

[33] E. Jääskä, J. Lehtinen, J. Kujala, and O. Kauppila, "Game-based learning and students' motivation in project management education,"

Proj. Leadersh. Soc., vol. 3, p. 100055, 2022, doi: 10.1016/j.plas.2022.100055.

[34] E. G. M. Puma *et al.*, "How universities have responded to e-learning as a result of Covid-19 challenges," *Period. Eng. Nat. Sci.*, vol. 10, no. 3, pp. 40–47, May 2022, doi: 10.21533/pen.v10i3.3008.

[35] A. Tapani and A. O. Salonen, "Identifying teachers' competencies in Finnish vocational education," *Int. J. Res. Vocat. Educ. Train.*, vol. 6, no. 3, pp. 243–260, Dec. 2019, doi: 10.13152/IJRVET.6.3.3.