Jurnal Pemberdayaan Masyarakat
Volume 4 Nomor 4 Tahun 2025 | Hal. 869–884
ykgm.org

ISSN 2962-8091
DOI: 10.46843/jpm.v4i4.579

Mediator of Technology Competence and Solar Panel Module on Satisfaction, Motivation, and Self-Regulated Learning

Farid Baskoro[1]*, Achmad Imam Agung[2], Fendi Achmad[3], Rifqi Firmansyah[4], Aristyawan Putra Nurdiansyah[5], Wahyu S Putro[6]
[1-5]Universitas Negeri Surabaya, Indonesia
[6]Nanyang Technological University, Singapore

ABSTRACT

The development of digital technology requires higher vocational education, particularly in engineering, to emphasize practical competency and independent learning. This study aims to analyze active engagement as a mediator in the relationship between technological competency and practical modules on learning satisfaction, motivation, and self-regulated learning. The study used a quantitative-correlation approach with the Structural Equation Modeling–Partial Least Squares (SEM-PLS) analysis technique on 80 electrical engineering students, Surabaya State University (Unesa) who were selected using purposive sampling. The results showed that technological competence had a significant effect on active involvement ($\beta = 0.291$; $p < 0.01$) and motivation ($\beta = 0.276$; $p < 0.05$). The practical module has a significant effect on learning satisfaction, active engagement is the most potent factor influencing learning satisfaction, motivation, and self-regulated learning. Active engagement as a crucial mediating mechanism within the technology-enhanced learning framework is related to engagement-driven learning through collaborative projects, problem-based learning, and digital simulations. These findings are relevant to contributing to the digital transformation of vocational education and the needs of the renewable energy industry.

ARTICLE INFORMATION

Keywords:
active engagement; learning satisfaction; motivation; practicum module; self-regulated learning; technological competence

Correspondent Author:
Farid Baskoro

Email:
faridbaskoro@unesa.ac.id

Recommended citation: Baskoro, F., Agung, A. I.., Achmad, F., Kholis, N., Nurdiansyah, A. P., & Putro, W. S. (2025). Mediator of Technology Competence and Solar Panel Module on Satisfaction, Motivation, and Self-Regulated Learning. *Jurnal Pemberdayaan Masyarakat, 4*(4), 869-884.

INTRODUCTION

Rapid technological developments in the digital era require higher education institutions to transform their learning strategies, particularly in the context of vocational and technical education. Students are expected to not only master theory but also be able to apply knowledge practically and independently (Harefa, 2024; Loksa et al., 2022). Self-regulated learning in technology is crucial for equipping individuals to adapt to rapid technological developments and solve problems independently. Students need to possess self-regulated learning because it fosters attitudes that encourage individuals to act freely for the benefit of themselves and others, and to gain satisfaction from their efforts (Syahrial et al., 2024). For example, in engineering learning, learning strategies are needed that can enhance student competence, motivation, satisfaction, and learning independence through the use of technology. Furthermore, self-regulated learning and optimal technological provision can create an effective learning environment (Jeong, 2022).

One crucial component of an effective learning process is active student engagement. Active engagement reflects students' cognitive, affective, and behavioral participation in the learning process, which has been shown to play a role in improving various learning outcomes (Munna & Kalam, 2021). Active engagement is also a key foundation for meaningful learning (Kusmawan et al., 2025). Without this engagement, learning activities tend to be mechanical and do not provide space

for students to truly understand, reflect on, or relate the material to their personal experiences. In modern educational environments, active engagement is not only an indicator of activeness but also reflects the quality of students' interactions with the material, instructor, and learning context. Therefore, creating situations that encourage active participation is essential in designing effective learning strategies and media. However, this engagement does not simply emerge; it is influenced by various factors, such as technological competence and the quality of the practicum modules used (Lintangesukmanjaya et al., 2025).

Active engagement is key to creating a meaningful and effective learning process. Classroom designs that support active learning significantly strengthen student engagement and learning experiences (Peng et al., 2022). A systematic review supports this by adding that collaboratively and interactively designed blended learning structures can enhance academic, cognitive, and affective engagement (De Bruijn-Smolders & Prinsen, 2024). Even in medical education settings, evidence shows that active learning lowers barriers to participation and improves academic performance, highlighting that without active engagement, pedagogical interventions will not deliver optimal results (Lim et al., 2022). However, active engagement and self-regulated learning are currently low due to inappropriate learning media and models (Galatsopoulou et al., 2022; Pramesworo et al., 2023). Another study also found that 56.48% (more than half of the sample) of students were identified as having low behavioral engagement and self-regulation (Estévez et al., 2021). One medium or tool that supports increasing student learning independence in active learning so far is learning modules (Syahrial et al., 2019). Learning modules can be used with integration into practice-based learning that is relevant to technological developments.

One form of practice-based learning that is highly relevant to current developments in renewable energy technology is the solar panel practicum. Through this practicum, students not only gain a theoretical understanding of the working principles of photovoltaic systems but also gain hands-on experience in designing, installing, and technically evaluating the performance of solar panels. Given the complexity and applicability of this practicum material, a high level of learning engagement is required to enable students to grasp the concepts in depth and develop adequate technical skills. Therefore, increasing learning satisfaction is crucial so that students feel that their practicum experience is meaningful and relevant (Pandita & Kiran, 2023). Furthermore, high learning motivation is needed so that students are encouraged to explore the material independently and not just limited to lecturer instructions. Furthermore, selft-regulated learning is also crucial in facing the challenges of practicum learning, as students are expected to be able to plan, monitor, and evaluate their own learning process reflectively (Raković et al., 2022). The relationship between these three aspects plays a crucial role in the success of the practice and application of effective learning media, especially in solar panels that are oriented towards mastering 21st century competencies.

Based on the previous problems and analysis, currently there is no relevant research on the application of technology in studying learning experiences to support SRL, especially in energy material. Maka, to provide a learning experience, a solar panel model was designed that is integrated with technology. This direct connection and contextual and applicable display are expected to increase student active engagement. Along with the application of technology, skills in conceptual understanding, device use, and analysis and evaluation of the technology are also needed (Mardatillah et al., 2025; Mattar et al., 2022). This is very helpful and necessary in learning solar panel technology. As a mediating variable, active involvement connects technological skills and the use of practical modules according to learning outcomes, which focuses on aspects of learning satisfaction, learning motivation, to self-regulated learning (SRL). In fulfilling effectiveness, all of these aspects are very important in assessing and influencing the learning process in modern times that emphasize independent, reflective, and student-centered learning. Therefore, research was conducted to analyze

the role of active involvement as an indirect influence on the influence of technological competence and solar panel practical modules on student learning satisfaction, learning motivation, and independent learning. This novelty lies in a more complex and reflective conceptual model of variable relationships in modern learning behavior. The correlation between learning satisfaction, motivation, and SRL (affective and metacognitive aspects) is more emphasized. The results of the study are expected to contribute to innovative learning planning, especially in developing more effective learning strategies oriented towards achievement in engineering learning.

METHOD

The type of research used is quantitative research with a correlation-quantitative approach. Correlation research aims to determine and analyze the influence of the relationship to active involvement between technological competencies and practical modules on students' motivational responses, self-satisfaction, and self-regulated learning (Hussain et al., 2024; Sapitri et al., 2025). The research flow can be clearly seen in Figure 1. The research was conducted in the engineering study program of Surabaya State University, with a population of electrical engineering students in the 2024/2025 semester. The research sample was obtained using a purposive sampling technique by taking 80 students who used practical modules according to the research needs (Ahmad & Wilkins, 2025).



Figure 1. Research flow: Quantitative-correlation approach

In the research process, during the instrument development stage, a validity analysis was conducted to determine the validity value of the research instruments used. Furthermore, after data collection, the data were analyzed using a correlation test using Structural Equation Modeling (SEM) with a Partial Least Squares (PLS) approach. This was done to describe the relationship between variables simultaneously and validly. Through a statistical and systematic framework, all relationships can be described sequentially and grouped (Magno et al., 2022).

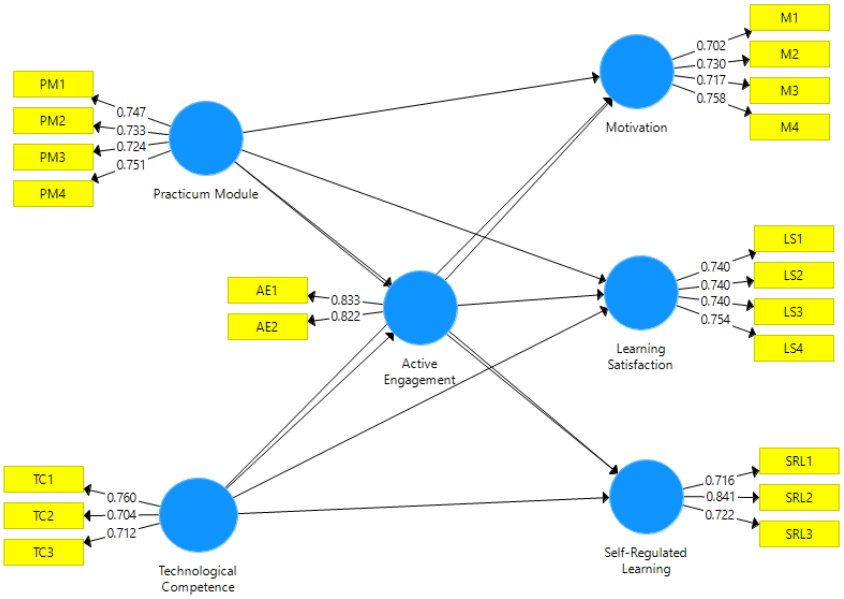


Figure 2. Structural model of active engagement, technological competence, practicum module, and learning outcomes

The initial correlation results in Figure 2 reflect that the practicum module and technological skills act as exogenous variables that directly and indirectly influence students' active engagement. A clearly designed, relevant, functional, and visually appealing practicum module encourages students to act, feel (emotional engagement), and think deeply (cognitive engagement). As another exogenous variable, technological skills, which include operational skills, conceptual understanding, and evaluation of technology applications, enable students to access and utilize digital media effectively, enhancing their active engagement. Furthermore, this active engagement acts as an important mediator; students who actively participate tend to have higher learning motivation. This motivation, complemented by strong emotional, behavioral, and cognitive engagement, strengthens learning satisfaction and self-regulated learning. Through SEM-PLS, all these relationships were tested simultaneously, including both direct and indirect pathways (Shehzad et al., 2022), such as the practicum module impact on SRL through active engagement and motivation, or technological skills on learning satisfaction and SRL through motivation and engagement.

Strengthened by several studies finding that technology proficiencies or digital competences directly increase self-regulated learning, and act as a mediator between online learning interactions and SRL ($\beta \approx 0.197 - 0.358$, significant $p < .05$). The SRL framework, integrated with the concept of digital competence, describes the forethought (planning and motivation), performance (execution and monitoring), and reflection (self-evaluation) phases, which are structurally interrelated in influencing engagement and learning outcomes. The Dig-Comp theoretical model also states that digital competence influences digital autonomy and attitudes, which align with self-efficacy and self-regulation in the context of higher education.

RESULTS AND DISCUSSION

The results of the convergent validity test show that all indicators in each research construct have outer loading values above 0.70, which means they have met the minimum criteria for convergent validity. Indicators in the Active Engagement construct (AE1 = 0.833; AE2 = 0.822) and Self-Regulated Learning (SRL2 = 0.841) have the highest values, so it can be concluded that both are the strongest representation of the construct being measured. Meanwhile, several indicators such as Motivation (M1 = 0.702) and Technological Competence (TC2 = 0.704) are close to the lower limit, but remain statistically valid and can be retained in the measurement model. Overall, these results confirm that each indicator is able to explain its construct consistently and accurately. More clearly, the external loading results obtained for each construct can be seen in Table 1.

Table 1. Outer loading result

Construct	Indicator	Outer Loading
Active Engagement	AE1	0.833
	AE2	0.822
Learning Satisfaction	LS1	0.740
	LS2	0.740
	LS3	0.740
	LS4	0.754
Motivation	M1	0.702
	M2	0.730
	M3	0.717
	M4	0.758
Self-Regulated Learning	SRL1	0.716
	SRL2	0.841
	SRL3	0.722
Practicum Module	PM1	0.747
	PM2	0.733
	PM3	0.724
	PM4	0.751
Technological Competence	TC1	0.760
	TC2	0.704
	TC3	0.712

The results of this study indicate that the interaction between technological competency, practicum modules, and active student engagement largely determines the effectiveness of solar panel practicum learning for Unesa electrical engineering students. SEM-PLS analysis shows that active engagement is the most central variable, as well as the main mediator linking technological skills with learning outcomes. First, the Active Engagement construct (AE1 – behavioral & emotional, AE2 – cognitive) obtained a high loading (0.822–0.833) and a significant influence on learning satisfaction, motivation, and self-regulated learning. Second, the Learning Satisfaction construct (LS1–LS4) with stable loading values (0.740–0.754) shows that student satisfaction is greatly influenced by the relevance of the practicum content to the electrical engineering competency requirements. Third, the Motivation construct (M1–M4) shows a valid contribution even though the loading is at the lower limit (0.702–0.758).

Fourth, the Self-Regulated Learning (SRL) construct, with a dominant indicator of self-control (SRL2 = 0.841), confirms that electrical engineering students have strong potential to be independent in managing learning strategies. Fifth, the Practicum Module construct (PM1–PM4) is valid and reliable (loading 0.724–0.751), but its influence is limited: significant only on learning satisfaction, not on motivation or active engagement. The practicum module acts as structural support but is less able to encourage student engagement. This shows the limitations of conventional instructional media that are still instructive, so that it requires the integration of collaborative or problem-based learning pedagogical strategies to stimulate engagement truly. Sixth, the Technological Competence construct (TC1–TC3) with a loading of 0.704–0.760 is proven to act as a driver of engagement and motivation and has an indirect effect on satisfaction and self-regulated learning through active engagement.

In general, the results show that the construct (0.702-0.841) meets the criteria for a stable external load contribution value. Therefore, this research instrument can be said to be valid and reliable. Indicators in the instrument meet the reliability criteria for active engagement, learning satisfaction, motivation, SLR, practice modules, and technological competence. Therefore, it meets the

requirements for further construct reliability testing (Composite Reliability, Cronbach's Alpha) and discriminant validity before proceeding to the structural analysis stage in the correlation of latent variables (Dzin & Lay, 2021; Hair et al., 2017).

Tabel 2. Construct reliability and validity

	Cronbach's Alpha	Rho_A	Composite Reliability	Average Variance Extracted (AVE)
Active Engagement	0,640	0,640	0,813	0,785
Learning Satisfaction	0,830	0,830	0,832	0,653
Motivation	0,803	0,801	0,817	0,628
Practicum Module	0,824	0,825	0,828	0,646
Self-Regulated Learning	0,734	0,738	0,805	0,681
Technological Competence	0,650	0,648	0,769	0,627

Based on Table 2, the Composite Reliability (CR) value is above 0.70 with a range of 0.769–0.832 in the latent variable, meeting the internal consistency criteria (Hair et al., 2024). Meanwhile, the Average Variance Extracted (AVE) value is > 0.5. This provides a conclusion that more than 50% of the indicator variance is relevant and can be associated with the construct. Overall, these results indicate that the instrument is feasible and has strong convergent validity. When explicitly analyzed, it was found that AVE has the highest value (0.785), which indicates a very strong contribution of indicators in explaining the latent variable. It can also be said to be a representative construct. In addition, the average results of the Cronbach's Alpha and rho_A values are 0.640 and technological competence is $\alpha = 0.650$; rho_A = 0.648. This condition can be explained by the nature of Cronbach's Alpha which tends to be conservative and sensitive to a relatively small number of indicators.

Next is discriminant validity, which is crucial because it serves to highlight the different concepts between each construct. Structural model estimation results can be biased without adequate discriminant validity. Therefore, exploring discriminant validity is crucial in Structural Equation Modeling (SEM)-based research, particularly with the Partial Least Squares (PLS) approach. Discriminant validity testing in this study was conducted using two procedures: the Fornell–Larcker criterion and the Heterotrait-Monotrait Ratio (HTMT) (Fornell & Larcker, 1981; Hair et al., 2024). The square root of the Average Variance Extracted (AVE) of each construct must be higher than the correlation between other constructs. Referring to the Fornell–Larcker Criteria, the construct has good discriminatory ability.

Meanwhile, the HTMT approach is used as an additional method to increase the sensitivity of the test, with a cutoff value <0.90 indicating the absence of multicollinearity problems between constructs (Henseler et al., 2015). A combination of discriminant validity and two other approaches is used in detecting discrimination problems between latent variables. Thus, the discriminant validity test in this study not only confirms the contextual differences between constructs but also ensures the integrity of the measurement model before testing causal relationships in the structural model.

Tabel 3. Discriminant validity with fornell-larcker criterion

	Active Engagement	Learning Satisfaction	Motivation	Practicum Module	Self-Regulated Learning	Technological Competence
Active Engagement	0.828					
Learning Satisfaction	0.503	0.743				
Motivation	0.464	0.468	0.727			
Practicum Module	0.240	0.416	0.334	0.739		
Self-Regulated Learning	0.573	0.616	0.520	0.358	0.762	
Technological Competence	0.340	0.345	0.449	0.442	0.398	0.726

Based on Table 3, it is clear that all indicators have very low VIF values, ranging from 1.130 to 1.523. This value is far below the general threshold of 5.0 (Hair et al., 2017), and is even in the very safe category (<3.3) to avoid multicollinearity problems between indicators. This finding confirms that each indicator used in the study has a unique contribution in reflecting its respective construct, so there is no redundancy between measurement items. Thus, the instrument used can be confirmed to be statistically stable and meets the basic assumptions of PLS-SEM analysis. The output of the structure test can be seen in Figure 3, and direct and indirect relationships can be seen in Table 4.

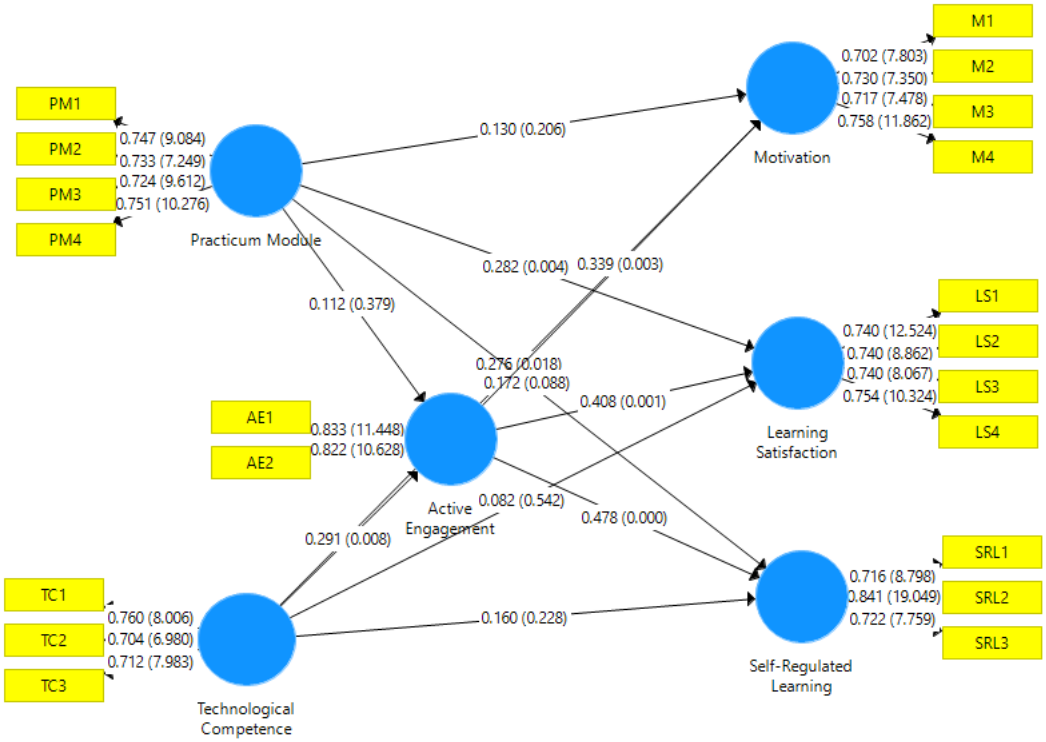


Figure 3. Structure test result of inner model (path coefficients & p-value) and outer model (outer loding & t-value)

Table 4. Path coefficients diret relationship

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Active Engagement -> Learning Satisfaction	0.408	0.406	0.116	3.528	0.000
Active Engagement -> Motivation	0.339	0.334	0.114	2.980	0.003
Active Engagement -> Self-Regulated Learning	0.478	0.483	0.078	6.126	0.000
Practicum Module -> Active Engagement	0.112	0.107	0.127	0.882	0.378
Practicum Module -> Learning Satisfaction	0.282	0.295	0.101	2.791	0.005
Practicum Module -> Motivation	0.130	0.137	0.104	1.251	0.211
Practicum Module -> Self-Regulated Learning	0.172	0.186	0.101	1.703	0.089
Technological Competence -> Active Engagement	0.291	0.312	0.110	2.645	0.008
Technological Competence -> Learning Satisfaction	0.082	0.079	0.135	0.604	0.546
Technological Competence -> Motivation	0.276	0.280	0.119	2.317	0.021
Technological Competence -> Self-Regulated Learning	0.160	0.153	0.131	1.216	0.224

The results of the path coefficient tests in Table 4 show that Active Engagement plays a central role in influencing various learning outcomes. Specifically, Active Engagement has been shown to have a significant influence on Learning Satisfaction ($\beta = 0.408$; $T = 3.528$; $p < 0.001$), Motivation ($\beta = 0.339$; $T = 2.980$; $p < 0.01$), and Self-Regulated Learning ($\beta = 0.478$; $T = 6.126$; $p < 0.001$). These results confirm that active student engagement is not merely a supporting factor, but rather a key determinant capable of bridging various dimensions of the learning experience. Theoretically, these findings are consistent with (Amiruddin et al., 2023), where active engagement in learning increases the satisfaction of basic psychological needs (autonomy, competence, relatedness), which in turn fosters intrinsic motivation and self-regulation. This indicates that electrical engineering students are not sufficient to have access to practicum modules or technological facilities; the quality of their active engagement—marked by discussion participation, curiosity, and cognitive reflection—is a determining factor in learning success. This finding is in line with the self-determination theory framework (Ryan & Deci, 2023), which emphasizes that active engagement strengthens students' autonomy and intrinsic motivation. Thus, Active Engagement can be categorized as a mediating construct that strengthens the relationship between learning support and student academic achievement.

Meanwhile, the Practicum Module showed a significant positive influence only on Learning Satisfaction ($\beta = 0.282$; $T = 2.791$; $p < 0.01$), but does not affect Active Engagement, Motivation, or Self-Regulated Learning ($p > 0.05$). This indicates that the practical module places more emphasis on instructional aspects that increase student satisfaction with the learning process, but does not directly stimulate their engagement or self-regulation. Conversely, Technological Competence significantly contributes to Active Engagement ($\beta = 0.291$; $T = 2.645$; $p < 0.01$) and Motivation ($\beta = 0.276$; $T = 2.317$;

$p < 0.05$), but it does not affect Learning Satisfaction or Self-Regulated Learning ($p > 0.05$). This finding strengthens the argument that mastery of digital technology is an important factor in increasing active participation and motivation of students, in line with theory (Widiasih et al., 2025), However, learning satisfaction and self-regulation skills require additional factors such as more adaptive learning design and personalized learning experiences. Thus, this study empirically contributes to the literature by confirming the role of Active Engagement as a central variable linking technological competence and instructional design (practical modules) with student satisfaction, motivation, and self-regulation. This means that, in a vocational context, student learning satisfaction is more quickly formed when practical instructions are clearly structured, applicable, and directly support work competence.

An important finding here is that student motivation is primarily driven by technological competence ($\beta = 0.276$; $p < 0.05$) and active involvement ($\beta = 0.339$; $p < 0.01$). This confirms that electrical engineering students are more motivated when they master digital devices and applications, as this mastery provides a sense of confidence and control in facing the challenges of renewable energy labs. Lab modules alone are not enough to generate motivation unless they are combined with technology that provides authentic learning experiences. However, the path results indicate that self-regulation can only be significantly improved through active engagement ($\beta = 0.478$; $p < 0.001$), not through the practicum module or technological competency directly. This means that students are able to plan, monitor, and reflect on their learning when they are truly actively involved, not just because of the availability of instructions or technological devices. This finding strengthens the argument that technological competency is not an end in itself, but rather an enabler that improves the quality of student interaction with practicum materials. Technologically savvy electrical engineering students are more willing to try, discuss, and evaluate experiments, making their learning experience more meaningful. Meanwhile, if we look at the results of the indirect relationship test in Table 5, we can see the importance of the role of active involvement in learning outcomes.

Table 5. Path coefficients indiret relationship

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
Practicum Module -> Active Engagement -> Learning Satisfaction	0.046	0.047	0.057	0.798	0.425
Technological Competence -> Active Engagement -> Learning Satisfaction	0.119	0.126	0.058	2.046	0.041
Practicum Module -> Active Engagement -> Motivation	0.038	0.039	0.049	0.769	0.442
Technological Competence -> Active Engagement -> Motivation	0.098	0.104	0.053	1.868	0.002
Practicum Module -> Active Engagement -> Self-Regulated Learning	0.053	0.051	0.062	0.863	0.388
Technological Competence -> Active Engagement -> Self-Regulated Learning	0.139	0.152	0.064	2.156	0.031

The results of the indirect relationship test in Table 5 demonstrate the important role of Active Engagement as a mediating variable between Technological Competence and student learning outcomes. Specifically, Technological Competence significantly influences Learning Satisfaction ($\beta = 0.119$; $T = 2.046$; $p < 0.05$), Motivation ($\beta = 0.098$; $T = 1.868$; $p = 0.002$), and Self-Regulated Learning

(β = 0.139; T = 2.156; p < 0.05) through Active Engagement. These findings indicate that technological competence does not directly increase student satisfaction, motivation, or self-regulation, but rather works through mechanisms that increase active engagement in the learning process. This is consistent with the Technology-Enhanced Learning framework (Zhang et al., 2024), which emphasizes that the use of new technologies only has a positive impact when students are truly engaged in using them for exploration, interaction, and knowledge construction. In other words, technology is an enabler, but not the ultimate determinant of learning quality without active engagement.

In contrast, the Practicum Module did not show a significant indirect effect on Learning Satisfaction, Motivation, or Self-Regulated Learning through Active Engagement (p > 0.05). This indicates that although the practicum module serves as a structural learning resource, its presence does not automatically stimulate active student engagement, leading to higher learning outcomes. This condition strengthens the argument that material-based learning instruments (such as modules) require additional pedagogical strategies, such as the integration of problem-based learning or collaborative learning, to optimally encourage active engagement (Sadikin & Hardianti, 2021).

Conceptually, these findings provide an important contribution to the literature by affirming the position of Active Engagement as a crucial mediating mechanism in the context of technology-based learning. Research findings on active engagement refer to students' conscious and sustained participation in the learning process (Nkomo et al., 2021). Actively engaged students are not only physically present in class but also demonstrate initiative in asking questions, discussing, completing assignments, and exploring material beyond that presented by the lecturer. This engagement reflects intrinsic motivation to learn and a strong desire to understand the material in depth. Through active engagement, students can develop critical, reflective, and collaborative thinking skills, which are crucial in building meaningful and applicable understanding (Liu et al., 2024). Active engagement in learning consists of two main aspects, namely behavioral and emotional (AE1) and cognitive (AE2) (Bond et al., 2021; Heikkinen et al., 2025; Naibert et al., 2022).

Behavioral engagement reflects students' actual involvement in learning activities, such as attendance, completing assignments, following instructions, and participating in class discussions or lab work. Emotional engagement refers to students' affective responses to the learning process, including feelings of enjoyment, interest, or appreciation in the academic environment. This relates to technological proficiency, where the more they enjoy technology, the more their active engagement increases. It describes an individual's ability to understand, operate, and utilize various digital devices and applications to support learning activities (Tzafilkou et al., 2022). This proficiency encompasses three main aspects: conceptual understanding of technology, technical skills in its use, and evaluative skills in selecting and adapting technology relevant to academic or practical needs (Schwarz et al., 2024). Students with high technological proficiency tend to be more independent, adaptive, and able to access and manage information effectively in the ever-evolving digital era. Technological proficiency encompasses three important aspects: operational skills (TC1), conceptual understanding (TC2), and application and analysis skills (TC3).

Technological competency has been shown to have a transformative impact on learning outcomes only when students are actively engaged in the process, while practicum modules still tend to be instructional in nature and are less able to activate the mediative role of active engagement. Previous research has not maximized the use of technology in active engagement to increase motivation and independence. Therefore, this study recommends that curriculum development and learning strategies should place greater emphasis on creating an environment that encourages active technology-based engagement, rather than simply providing practicum materials. One of them is through a practical module that emphasizes the learning process with modern technology.

A practicum module is a structured learning resource designed to guide students in systematically carrying out practicum activities. This module not only contains technical instructions for practicum steps but also includes conceptual explanations, learning objectives, and provocative questions that encourage students to think critically and reflectively. With a practicum module, the learning process becomes more focused, independent, and can take place even without direct supervision. As a learning support tool, the practicum module plays a crucial role in guiding students throughout the practicum process. Four main aspects determine module quality: readability and clarity (PM1), content relevance (PM2), module functionality (PM3), and visual appearance and structure (PM4) (Cabouat et al., 2025; Santoso & Putra, 2021). Readability and clarity reflect how easily students understand the module's content, both in terms of language, technical terms, and the flow of instructions presented. Modules written in clear and systematic language are easier to understand and follow.

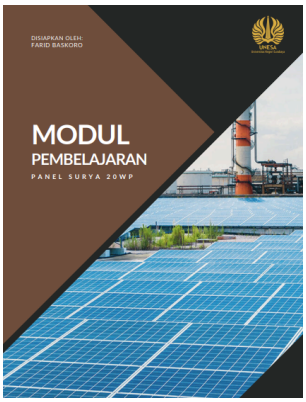


Figure 4. Practicum module cover

Figure 4 shows the cover of the solar panel practicum module used in this study. The cover of the solar panel practicum module reflects the Visual Appearance and Structure aspects, which are important parts of the learning module variables. The cover design is designed with a neat and proportional visual composition, displaying elements such as the module title, institutional logo, and solar panel illustrations in a structured and easily recognizable manner. The choice of contrasting yet harmonious colors creates a professional and attractive impression, which aims to increase initial interest and facilitate student identification of the module's contents. The clarity of typography, layout harmony, and the use of thematic images support readability and visual appeal, so that the cover not only functions as a complement but also strengthens the module's pedagogical function through representative visual presentation. Besides that, content relevance refers to the suitability of the material in the module to the objectives of the practicum and its relationship to the theory being studied. Relevant content will help students effectively connect theory and practice, which can also increase motivation.

Learning motivation is a psychological force that drives students to engage, persist, and succeed in the learning process. Learning persistence reflects the extent to which students can persist in the face of difficulties, remain consistent in completing assignments, and persist. Persistent students demonstrate a high level of commitment to the learning process, even when faced with obstacles or challenges (Ryan & Deci, 2023; Schunk et al., 2022). This relates to learning satisfaction, which reflects the extent to which students are satisfied with their learning experiences, including the process, interactions, and outcomes. Four main aspects shape learning satisfaction: satisfaction with learning materials and strategies, satisfaction with interaction and involvement, satisfaction with media, technology, and facilities, and satisfaction with learning outcomes and impact. Increased motivation can also be driven by reader or user interest. In this case, visual representation is highly influential. In

reality, 3D visual representation is scarce in module applications, especially in current solar modules (Hong et al., 2024). Therefore, 3D representation provides a novelty that can increase learning motivation.

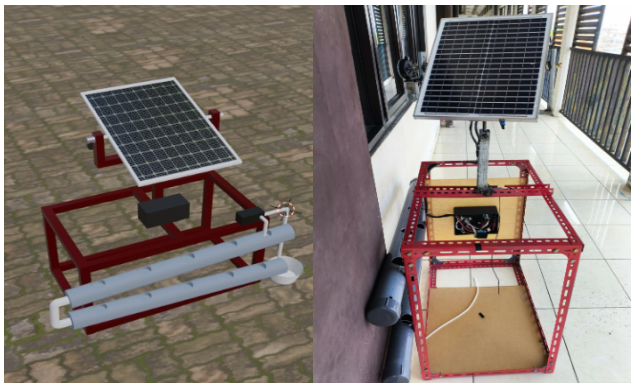


Figure 5. Panel view in software and direct application

Figure 5 is a representation of a three-dimensional (3D) model created using Blender software as part of the visualization of the solar panel practicum tool in this study. The design features a sturdy red metal frame as a support for the solar panel, which is positioned at an angle to optimize sunlight absorption. Below the panel are several supporting components such as a black box representing the solar charge controller and energy storage battery. At the bottom of the frame are also visible two parallel gray pipes designed as a simulation medium for the use of electrical energy for irrigation systems. This 3D model serves to provide a visual depiction of the tool being developed and helps students understand the structure, function, and workflow of the renewable energy-based learning system more concretely. This visualization also supports the module's display aspect and increases student active involvement through a project-based learning approach. Increased satisfaction in line with the use of relevant modules and learning.

Satisfaction with learning materials and strategies encompasses student perceptions of the clarity, relevance, and integration of learning content with the strategies used by lecturers. When material is presented in an engaging and easy-to-understand manner, students tend to be more satisfied and motivated (Aladib et al., 2024; Enyoojo et al., 2024; Hassan et al., 2024). This emerging interest triggers independent learning (SRL) to manage their learning process independently, responsibly, and with self-awareness without relying entirely on external direction. This variable consists of three main aspects: planning and self-monitoring, control, and reflection and evaluation (Broadbent & Poon, 2015). Planning encompasses students' ability to set learning goals, manage time, choose strategies, and design the steps needed to achieve learning targets. Students who have good planning tend to be more focused and prepared in facing the learning process. Controlling arises from factors within learning, including media and tools that support the learning process and foster independence. This can be triggered by active involvement and competent use of technology to support independence. Meanwhile, reflection aims to enable individuals to begin to move on from previously completed stages and significantly improve learning outcomes. Conceptually, this study confirms that active engagement is the key link between technological competence and learning outcomes. Without active engagement, technology becomes a passive instrument, and practical modules serve only as guides without generating any motivational or regulatory impact. The practical implication is that vocational engineering learning at Unesa needs to be designed not only by providing technological modules and devices, but also by creating an engagement-driven learning environment, for example through the integration of 3D simulations, project-based learning, and independent reflection mechanisms.

CONCLUSION

This study found that active engagement is the primary determinant bridging the relationship between technological competence and learning outcomes of Unesa electrical engineering students. Path test results indicate that active engagement has a significant effect on learning satisfaction (β = 0.408; p < 0,001), motivation (β = 0.339; p < 0.01), and self-regulated learning (β = 0.478; p < 0.001). Students' technological competencies have been shown to increase active engagement (β = 0.291; p < 0.01) dan motivasi (β = 0.276; p < 0.05), However, it does not have a direct impact on satisfaction or learning independence. In contrast, the practical module only has a significant impact on satisfaction (β = 0.282; p < 0.01), but not strong enough to drive motivation or active engagement. These findings confirm that technological mastery and the availability of instructional modules are only effective if accompanied by cognitive, affective, and behavioral student engagement in the learning process. They strengthen the technology-enhanced learning literature and self-determination theory by emphasizing the importance of psychological factors such as active engagement in optimizing technical vocational learning. Practically, as a scientific contribution, engineering learning needs to be designed to facilitate active student participation through project-based approaches, collaboration, and contextual technology integration, especially in science and technology learning. This also emphasizes the need for practicum modules designed not only as technical guides, but as learning media that stimulate engagement and intrinsic motivation. This research is still limited to a sample of 80 electrical engineering students at Unesa, so the generalizability of the results needs to be tested in other vocational engineering contexts, both at the national and international levels. Future research directions are suggested to develop interactive digital-based practicum modules that combine virtual laboratories, augmented reality, or gamified learning environments, so that student engagement can be encouraged more intensively. Thus, these findings not only strengthen the theoretical framework but also provide concrete recommendations for the development of vocational engineering learning strategies that are relevant to the demands of the digital transformation era and the needs of the renewable energy industry.

REFERENCES

Ahmad, M., & Wilkins, S. (2025). Purposive Sampling in Qualitative Research: A Framework for the Entire Journey. *Quality & Quantity, 59*(2), 1461–1479.

Aladib, B. A., Wicaksono, P. A., & Susanto, N. (2024). Engineering Student Satisfaction and Loyalty: The E-Learning Effect. *World Journal of Advanced Research and Reviews, 22*(1), 1297–1306.

Amiruddin, A., Baharuddin, F. R., Takbir, T., & Setialaksana, W. (2023). May Student-Centered Principles Affect Active Learning and Its Counterpart? An Empirical Study of Indonesian Curriculum Implementation. *Sage Open, 13*(4).

Bond, M., Bedenlier, S., Marín, V. I., & Händel, M. (2021). Emergency Remote Teaching in Higher Education: Mapping the First Global Online Semester. *International Journal of Educational Technology in Higher Education, 18*(1), 50.

Broadbent, J., & Poon, W. L. (2015). Self-Regulated Learning Strategies & Academic Achievement in Online Higher Education Learning Environments: A Systematic Review. *The Internet and Higher Education, 27*, 1–13.

Cabouat, A., He, T., Isenberg, P., & Isenberg, T. (2025). PREVis: Perceived Readability Evaluation for Visualizations. *IEEE Transactions on Visualization and Computer Graphics, 31*(1), 1083–1093.

De Bruijn-Smolders, M., & Prinsen, F. R. (2024). Effective Student Engagement with Blended Learning: A Systematic Review. *Heliyon, 10*(23), e39439.

Dzin, N. H. M., & Lay, Y. F. (2021). Validity and Reliability of Adapted Self-Efficacy Scales in Malaysian Context Using PLS-SEM Approach. *Education Sciences, 11*(11).

Enyoojo, S. F., Ijah, C. E., Etukudo, E. M., Usman, I. M., Ezeonuogu, C. S., Adaramati, T., Kabanyoro, A., Diaz, M. E. F., Rosales, Y. D., & Aigbogun, E. (2024). Satisfaction and Learning Experience of Students Using Online Learning Platforms for Medical Education. *BMC Medical Education, 24*(1).

Estévez, I., Rodríguez-Llorente, C., Piñeiro, I., González-Suárez, R., & Valle, A. (2021). School Engagement, Academic Achievement, and Self-Regulated Learning. *Sustainability, 13*(6).

Galatsopoulou, F., Kenterelidou, C., Kotsakis, R., & Matsiola, M. (2022). Examining Students' Perceptions Towards Video-Based and Video-Assisted Active Learning Scenarios in Journalism and Communication Courses. *Education Sciences, 12*(2), 74.

Hair, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., & Thiele, K. O. (2017). Mirror, Mirror on the Wall: A Comparative Evaluation of Composite-Based Structural Equation Modeling Methods. *Journal of the Academy of Marketing Science, 45*(5), 616–632.

Hair, J. F., Sarstedt, M., Ringle, C. M., Sharma, P. N., & Liengaard, B. D. (2024). Going Beyond the Untold Facts in PLS–SEM and Moving Forward. *European Journal of Marketing, 58*(13), 81–106.

Harefa, D. (2024). Strengthening Mathematics and Natural Sciences Education Based on the Local Wisdom of South Nias: Integration of Traditional Concepts in Modern Education. *Haga : Jurnal Pengabdian Kepada Masyarakat, 3*(2), 63–79.

Hassan, E. A., Mohamed, A. M., Eltaib, F. A., & Khaled, A. M. S. (2024). Determinants of Nursing Students' Satisfaction with Blended Learning. *BMC Nursing, 23*(1), 766.

Heikkinen, S., Saqr, M., Malmberg, J., & Tedre, M. (2025). A Longitudinal Study of Interplay Between Student Engagement and Self-Regulation. *International Journal of Educational Technology in Higher Education, 22*(1), 21.

Hong, J., Hnatyshyn, R., Santos, E. A., Maciejewski, R., & Isenberg, T. (2024). A Survey of Designs for Combined 2D+3D Visual Representations. *IEEE Transactions on Visualization and Computer Graphics, 30*(6), 2888–2902.

Hussain, T., Ali, Z. H., & Naz, A. (2024). The Impact of Teacher Immediacy and Humor on Undergraduate Student Classroom Engagement: Evidence from Pakistan. *Journal of Development and Social Sciences, 5*(4), 386–395.

Jeong, K. O. (2022). Facilitating Sustainable Self-Directed Learning Experience with the Use of Mobile-Assisted Language Learning. *Sustainability, 14*(5), 2894.

Kusmawan, A., Rahman, R., Anis, N., & Arifudin, O. (2025). The Relationship Between Teacher Involvement in Curriculum Development and Student Learning Outcomes. *International Journal of Educatio Elementaria and Psychologia, 2*(1), 1–12.

Lim, J., Ko, H., Park, J., & Ihm, J. (2022). Effect of Active Learning and Online Discussions on the Academic Performances of Dental Students. *BMC Medical Education, 22*(1), 312.

Lintangesukmanjaya, R. T., Iswardani, A., Prahani, B. K., Jatmiko, B., & Supardi, Z. A. I. (2025). Improving Critical Thinking Skills of High School Students in Physics Learning with Smartphone-Simulation Assisted Inquiry Model. *Journal of Digitalization in Physics Education, 1*(2).

Liu, Y., Ma, S., & Chen, Y. (2024). The Impacts of Learning Motivation, Emotional Engagement and Psychological Capital on Academic Performance in a Blended Learning University Course. *Frontiers in Psychology, 15*.

Loksa, D., Margulieux, L., Becker, B. A., Craig, M., Denny, P., Pettit, R., & Prather, J. (2022). Metacognition and Self-Regulation in Programming Education: Theories and Exemplars of Use. *ACM Trans. Comput. Educ., 22*(4), 1–31.

Magno, F., Cassia, F., & Ringle, C. M. (2022). A Brief Review of Partial Least Squares Structural Equation Modeling (PLS-SEM) Use in Quality Management Studies. *The TQM Journal, 36*(5), 1242–1251.

Mardatillah, S. T., Shanty, S. K., Auliya, N., Lestari, N. A., & Rizki, I. A. (2025). Integrating Technology and Ethnophysics to Support Sustainable Education and Cultural Preservation Through Traditional Games of Gasing and Hula Hoop in Rotational Physics Learning. *Journal of Innovative Technology and Sustainability Education, 1*(1), 38.

Mattar, J., Ramos, D. K., & Lucas, M. R. (2022). DigComp-Based Digital Competence Assessment Tools: Literature Review and Instrument Analysis. *Education and Information Technologies, 27*(8).

Munna, A. S., & Kalam, M. A. (2021). Impact of Active Learning Strategy on the Student Engagement. *GNOSI: An Interdisciplinary Journal of Human Theory and Praxis, 4*(2), 96–114.

Naibert, N., Vaughan, E. B., Lamberson, K. M., & Barbera, J. (2022). Exploring Student Perceptions of Behavioral, Cognitive, and Emotional Engagement at the Activity Level in General Chemistry. *Journal of Chemical Education, 99*(3), 1358–1367.

Nkomo, L. M., Daniel, B. K., & Butson, R. J. (2021). Synthesis of Student Engagement with Digital Technologies: A Systematic Review of the Literature. *International Journal of Educational Technology in Higher Education, 18*(1), 34.

Pandita, A., & Kiran, R. (2023). The Technology Interface and Student Engagement Are Significant Stimuli in Sustainable Student Satisfaction. *Sustainability, 15*(10), 7923.

Peng, L., Deng, Y., & Jin, S. (2022). The Evaluation of Active Learning Classrooms: Impact of Spatial Factors on Students' Learning Experience and Learning Engagement. *Sustainability, 14*(8), 4839.

Pramesworo, I. S., Fathurrochman, I., Sembing, D., Bangkara, B. A., & Sudrajat, D. (2023). Relevance Between Blended Learning and Students' Independent Learning Curriculum: An Overview of Digital Age Education, Student and Teacher Engagement, Technological Resources. *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran, dan Pembelajaran, 9*(3), 858-869.

Raković, M., Bernacki, M. L., Greene, J. A., Plumley, R. D., Hogan, K. A., Gates, K. M., & Panter, A. T. (2022). Examining the Critical Role of Evaluation and Adaptation in Self-Regulated Learning. *Contemporary Educational Psychology, 68*, 102027.

Ryan, R. M., & Deci, E. L. (2023). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology, 68*, 60–67.

Sadikin, A., & Hardianti, R. D. (2021). Development of Emulsi (Electronic Module Practicum Articulate Storyline 3) to Support Self-Regulated Learning of Students. *Journal of Environmental and Science Education, 1*(2), 25–31.

Santoso, H., & Putra, P. H. (2021). Development & Evaluation of E-Learning Module Based on Visual and Global Preferences Using a User-Centered Design Approach. *International Journal of Emerging Technologies in Learning (iJET), 16*(15), 139-151.

Sapitri, V., Nurudin, M., Prasetyo, M. A., Qordowi, M. Y., Putra, M. H., & Azizah, N. (2025). The Relationship Between Flexible and Adaptive Behaviour Ability and Students' Tolerance Attitude: A Correlational Approach. *Action Research Journal Indonesia (ARJI), 7*(2), 1144 – 1158.

Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2022). *Motivation in Education: Theory, Research, and Applications* (5th ed.). Pearson.

Schwarz, S., Bieg, T., Svecnik, E., Schmölz, A., Geppert, C., & Gerdenitsch, C. (2024). Digital Competence Scale (DCS). *Nordic Journal of Digital Literacy, 19*(3), 126–143.

Shehzad, M. U., Zhang, J., Alam, S., & Cao, Z. (2022). Determining the Role of Sources of Knowledge and IT Resources for Stimulating Firm Innovation Capability: A PLS-SEM Approach. *Business Process Management Journal, 28*(4), 905–935.

Syahrial, S., Asrial, A., Kurniawan, D. A., & Pratama, R. A. (2019). Towards Improving the Critical Thinking Skills of Pre-Service Teachers in Indonesia. *Journal of Education and Learning (EduLearn), 13*(4), 575-582.

Syahrial, S., Asrial, A., Sabil, H., Azzahra, M. Z., & Nawahdani, A. M. (2024). Optimizing Learning through Gagne's Theory: Teaching Video Analysis for Prospective Teachers. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *8*(2).

Tzafilkou, K., Perifanou, M., & Economides, A. A. (2022). Development and Validation of Students' Digital Competence Scale (SDiCoS). *International Journal of Educational Technology in Higher Education, 19*(1), 30.

Widiasih, W., Adji, S. S., Firmansyah, J., Ekawati, R., Sumardani, D., & Chaw, E. P. (2025). Enhancing Student Engagement in Science Practicum in Distance Higher Education for Quality Education (SDG 4). *Jurnal Pendidikan IPA Indonesia, 14*(1).

Zhang, X., Qian, W., & Chen, C. (2024). The Effect of Digital Technology Usage on Higher Vocational Student Satisfaction: The Mediating Role of Learning Experience and Learning Engagement. *Frontiers in Education, 9*, 1508119.