Original Article
ISSN (Online): 2582-7472

ShodhKosh: Journal of Visual and Performing Arts
Special Issue on Art, Technology, and Society: Emerging Intersections in Visual and Performing Arts Research 7(2s)

SUPPORTIVE LEARNING ECOSYSTEMS IN TECHNOLOGY-ENHANCED ENGINEERING EDUCATION: EFFECTS OF TEACHER SUPPORT, PEER SUPPORT, AND DIGITAL LEARNING CONTEXT QUALITY ON STUDENT ENGAGEMENT VIA ACADEMIC SELF-EFFICACY

Krishna Kumar TP [1], Dr. Harwinder Kaur [2], Dr. Parikshit Mahankal [3], Dr. Sachin Chavan [4], Dr. Sandeep Kaur [5]

[1] Professor and Head, Nehru School of Management, NCERC, Pamapadi, Thiruvilwamala, Thrissur, Kerala, India
[2] Assistant Professor, Rayat Bahra University, Mohali, Punjab, India
[3] Associate Professor, Smt. Jayshree Sharadchandra Kothari Busines School, Mumbai, India
[4] Professor, Balaji Institute of International Business, Sri Balaji University, Pune, India
[5] Assistant Professor of English, Department of Languages, Amar Shaheed Baba Ajit Singh Jujhar Singh Memorial College, Bela, Ropar, Punjab, India

Received 10 December 2025
Accepted 28 January 2026
Published 28 March 2026

Corresponding Author
Krishna Kumar TP, tpk683@gmail.com

DOI
10.29121/shodhkosh.v7.i2s.2026.7356

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

Student engagement in technology-enhanced higher education is shaped not only by instructional design but also by the social and psychological ecosystem surrounding learners. This study examines how perceived teacher support, peer support in class, and technology-enhanced learning context quality influence student engagement through the mediating role of academic self-efficacy in engineering education. Using a quantitative cross-sectional design, data were collected from 423 undergraduate engineering students in India through purposive sampling. Covariance-based structural equation modeling (CB-SEM) was employed to test the hypothesized relationships. Results indicate that teacher support, peer support, and digital learning context quality significantly predict academic self-efficacy, which in turn exerts a strong positive effect on student engagement. All three support factors also demonstrate significant direct effects on engagement, confirming partial mediation. The model explains substantial variance in both academic self-efficacy and engagement, highlighting the importance of integrated support systems. The findings suggest that engagement in technology-rich classrooms emerges from a supportive learning ecosystem where relational trust and well-designed digital environments reinforce students' competence beliefs. This study extends engagement theory into technology-enhanced engineering education and provides practical guidance for faculty development, peer learning design, and digital pedagogy. Strengthening academic self-efficacy through supportive ecosystems may represent a critical strategy for sustaining engagement in modern higher education.

Keywords: Student Engagement, Teacher Support, Peer Support, Academic Self-Efficacy, Digital Learning, Engineering Education

How to cite this article (APA): TP, K.K., Kaur, H., Mahankal, P., Chavan, S., and Kaur, S. (2026). Supportive Learning Ecosystems in Technology-Enhanced Engineering Education: Effects of Teacher Support, Peer Support, and Digital Learning Context Quality on Student Engagement via Academic Self-Efficacy. *ShodhKosh: Journal of Visual and Performing Arts, 7*(2s), 484–493. doi: 10.29121/shodhkosh.v7.i2s.2026.7356

1. INTRODUCTION

Student engagement has become one of the most important measures of the effectiveness of learning in the development of education, especially in the higher education setting that is increasingly influenced by digital and technology-enhanced learning systems. Engagement reflects students' cognitive, emotional and behavioural investment in learning and is consistently associated with academic achievement, persistence and psychological well-being. A considerable amount of research has shown that engagement is not an individual trait as it is so deeply embedded in the social and instructional ecology of classrooms which includes the relational support and the context of learning Hu and Abu (2023), Upadyaya and Salmela (2013). Teacher support has been found many times to be a foundational predictor of student engagement and well-being in educational settings. Students who view their instructors as supportive, caring and responsive show greater involvement academically and show more emotional engagement with learning activities Romano et al. (2021), Tang and Wang (2024). Beyond the direct instruction guidance, teacher support conveys psychological safety and competence affirmation, allowing the students to approach the academic challenges with confidence. Empirical evidence has suggested that supportive teacher-student relationship work through such psychological mechanisms as self-efficacy, resilience, and motivation to explain engagement outcomes Fang 2025, Chen (2025). In the context of technology mediated environments, where interaction patterns change and students are often uncertain or experience technostress, teacher support is even more consequential for maintaining engagement Yang et al. (2025). Parallel to teacher influence, peer support in the classroom represents an important social resource that increases engagement. Classrooms of collaborative interaction, mutual encouragement, and common learning goals encourage better participation and persistence. Social support from peers adds to feelings of relatedness and belonging that are important elements in motivational functionality Sullanmaa et al. (2025), Wen et al. (2025). Studies on the use of social support systems in educational setting consistently reveal that students in supportive causal climates are seen to exhibit greater engagement and adaptive learning behaviours Kuokkanen et al. (2024). Importantly, peer support does not operate apart from instructional context, instead it works alongside teacher support to form a rich ecosystem of social reinforcement that maintains engagement.

In addition to interpersonal dynamics, the quality of the learning context itself has come into the forefront in the digital age of change. Technology enhanced learning environments such as AI aided education and digital learning platforms have given a new definition to the structure of interaction in class. When digital systems are recognized as accessible, meaningful and pedagogically appropriate they support the confidence and engagement of learners. On the other hand, poorly crafted or overly complex digital contexts may weaken psychological resources of students and alienate them from learning tasks Chen (2025), Liu et al. (2024). Recent studies have made it clear that the psychological impacts of digital learning environments are based not on the mere presence of technology but on the perceived quality, clarity, and support provided by instructional systems embedded within those technological environments Yang et al. (2025). A central psychological mechanism as a link between support and context and engagement is academic self-efficacy - ex. Student's belief in his own capability for successfully carrying out academic tasks. Self-Efficacy is a motivational engine and tells us to learn through effort, persistence, and emotional regulation within learning situations. Supportive environments enhance self-efficacy by offering validation of competence and minimizing perceptions of risk, which subsequently leads to engagement Tang and Wang (2024), Fang et al. (2025). Empirical models have robustly shown that teacher support predicts engagement indirectly via self-efficacy and other related psychological resources Romano et al. (2021), Chen (2025). However, a lot of the existing literature focuses on either isolated support mechanisms, or focusses on well being as such rather than engagement in technology enhanced higher education settings. The rapid growth of digital learning in engineering education and especially in developing economies like India increases the awareness of a need to understand the interplay of relational and contextual supports. Engineering programs have a growing tendency to use blended and technology-intensive instructional programs, but research combining quality of teacher support with peer support and the quality of the digital learning context within a common engagement model is scarce. Prior research has focused on teacher support or peer support separately Hu and Abu (2023), Sullanmaa et al. (2025), and there has been a general focus on well-being or anxiety outcomes in technology-enhanced learning research Chen (2025), Yang et al. (2025), while engagement has been overlooked. A powerful model in which academic self-efficacy is a mediating bridge among these factors can help explain how supporting ecosystems transform into active learning participation.

Therefore, the present study proposes an integrated framework in which perceived teacher support, peer support in class, and technology-enhanced learning context quality jointly influence student engagement through academic self-efficacy. By situating engagement within a social–psychological and instructional ecology, the study advances understanding of how supportive learning ecosystems operate in technology-rich engineering classrooms. Empirically testing this model using covariance-based structural equation modeling provides a rigorous approach to examining both direct and indirect pathways. The findings are expected to contribute to educational psychology by extending support–self-efficacy–engagement models into digitally mediated higher education contexts and to engineering education by offering evidence-based strategies for strengthening engagement through relational and contextual design.

2. HYPOTHESIS DEVELOPMENT

2.1. PERCEIVED TEACHER SUPPORT AND ACADEMIC SELF-EFFICACY

Perceived teacher support is the beliefs of students about whether or not instructors are available, responsive and interested in students academic growth. Educational psychology research routinely conceptualizes teacher support as an important environmental effect on student motivational beliefs and self-perceptions. Supportive teachers offer emotional encouragement, instructional clarity and autonomy - supportive interactions that signal commentary of competence affirmation and reduce performance anxiety. These experiences help build the confidence of students in their ability to fulfill the demands of the academic course of study. There is empirical evidence that teacher support predicts academic self-efficacy at all levels of education. When students see their instructors as approachable and supportive, they are more likely to view challenges as manageable, and they believe in their own ability to succeed Tang and Wang (2024). Similarly, technology-mediated learning environments demonstrate that perceived teacher support extends learning of learners by mediating the uncertainty experienced from digital systems Fang et al. (2025). Supportive instructional climates also promote resilience and adaptive coping that reinforce positive self-appraisals Chen (2025). Longitudinal and mediation studies further verify that teacher support serves as an antecedent of psychological resources that motivate engagement and achievement Romano et al. (2021). These results indicate that teacher support may not only act as a relational factor, but also represents a cognitive-motivational catalyst which influences how students think about their competence. Therefore, in technology-enhanced engineering classrooms where the demands for learning are complex and rapidly changing, teacher support (as perceived by students) is expected to promote students' academic self-efficacy.

H1: Perceived teacher support positively influences academic self-efficacy.

2.2. PEER SUPPORT AND ACADEMIC SELF-EFFICACY

Peer support acts as an alternative social resource that plays a significant role on the perception of their abilities in school. Classroom environments that encourage collaboration, helping one another, and having shared academic goals, contribute to the normalisation of effort and struggle between students. Within supportive peer groups social comparison processes can be used to increase self-efficacy through modelling of successful strategies and reinforcement of persistence. Empirical research on classroom social networks indicates that peer support facilitates students' development of belonging and competence that are important building blocks for motivational functioning Sullanmaa et al. (2025). Investigations into daily interactions have shown peer encouragement as the predictor of adaptive academic behaviours and emotional regulation Wen et al. (2025). Students within supportive climates of peers report greater engagement and lower levels of burnout, partly due to peer validation of the student's confidence around academic ability Kuokkanen et al. (2024). Within technology-enhanced learning contexts peer collaboration takes on a particular importance. Digital platforms often require collaborative problem-solving as well as the collaborative navigation of new systems. As peers provide informational and emotional assistance to students, they have experiences of mastery that strengthen their sense of self efficacy. Consequently, the effect of peer support on the academic self-beliefs is expected to be positive.

H2: Peer Support in class has a positive effect on academic self-efficacy.

2.3. TECHNOLOGY ENHANCED LEARNING CONTEXT QUALITY AND ACADEMIC SELF-EFFICACY

The rapid assimilation of technology into higher education has shifted scholarly attention to the psychological implications of technology-enhanced learning environments. Contextual quality is conceptualised in terms of students' perceptions of digital systems as structured, accessible and pedagogically meaningful. Intuitive and well supported technological learning environments work to mitigate cognitive overload and promote mastery experiences. Research conducted within AI-supported and digital learning contexts has suggested that, the psychological functioning of students very much depending on their interpretation of instructional design and embedded technological support Chen (2025). Poorly organised digital environments can be a source of technostress and uncertainty which undermines confidence Yang et al. (2025). Conversely, supportiveness by alternative environments fosters greater motivation and beliefs about ability among the students. Studies exploring structured management systems and digital learning conditions confirm that conditions around quality are predictors of both psychological functioning and learning in school Liu et al. (2024). These findings suggest that beliefs about one's academic capability that students form are not developed in isolation but determined by the usability and clarity of the learning environment. Engineering students transitioning within technologically intensive curricula are especially sensitive to the context of quality. Consequently, with a well-designed technology - enhanced learning context, it is expected that + academic self - efficacy improves.

H3: Technology Enhanced Learning: Context quality of technology enhanced learning positively influences on the academic self-efficacy.

2.4. ACADEMIC SELF-EFFICACY AND STUDENT ENGAGEMENT

Academic self-efficacy is a basic predictor of engagement. Students who believe in their ability to succeed become more likely to put their effort into learning, continue to work through difficulties, and engage thoroughly in learning tasks. Self efficacy influences cognitive engagement (strategic thinking), affective engagement (interest and enthusiasm), and behavioral engagement (participation and persistence). Empirical studies have repeatedly shown a link between self-efficacy and engagement in different academic contexts. Mediation studies have shown that teacher support mediates engagement, indirectly the same, through self-efficacy Tang and Wang (2024), Romano et al. (2021). Students with high self-efficacy view setbacks as temporary and controllable, and continue engaging in academic tasks. Technological enhanced contexts increase the salience of self efficacies, learners are faced with having to move around dynamic digital platforms and confidence becomes indispensable in being able to sustain participation. Findings from AI-based instruction suggest that psychological resources, namely competence beliefs, motivate results in engagement Chen (2025). Accordingly, academic self-efficacy is likely to have a strong positive effect on student engagement.

H4: Student engagement shall be positively influenced by academic self efficacy.

2.5. DIRECT EFFECTS OF SUPPORT AND CONTEXT ON ENGAGEMENT

While the self-efficacy represents a core mediator, previous research proposes that support and the learning context also have direct impacts on engagement. Teacher support has been repeatedly associated with increased participation, persistence and emotional investment in learning Tang and Wang (2024), Romano et al. (2021). Peer support is part of collaborative engagement and joint academic commitment Sullanmaa et al. (2025). Likewise, well-designed digital learning environments can be directly engaging in nature, as they offer interactive and meaningful experiences Yang et al. (2025). Hence, as well as indirect pathways through self-efficacy, direct relationships are expected.

H5: Student engagement is positively influenced by the perceived teacher support.

H6: The presence of peer support has a positive relationship with engagement among students.

H7: Technology enhanced learning context quality has a positive impact on student engagement.

2.6. MEDIATION ROLE OF THE ACADEMIC SELF-EFFICACY

A core assumption of education psychology is that environmental factors have impacts through psychological mechanisms. Supportive relationships and the quality of context help people become more competent, and this energises engagement. Several empirical models confirm the predictive role of teacher support in predicting engagement in terms of self-efficiency and motivational resources Fang et al. (2025), Chen (2025), Tang and Wang (2024). Extending this logic, the present study postulates that academic self-efficacy serves as a cohesive psychological pathway between teacher support and peer support and digital learning context quality and engagement. By testing a single mediator model, the study provides a parsimonious explanation of how relational and contextual supports are translated into active participation in learning.

H8a: Academic self-ease a efficacy mediates the relationship among teacher support and engagement.

H8b: Academic self- efficacy mediates the link between peer support and engagement.

H8c: Academic self - efficacy mediates the relationship between technology enhanced learning context quality and engagement.

3. RESEARCH METHODOLOGY

3.1. RESEARCH DESIGN

This study uses quantitative cross-sectional survey design to investigate the relationships between perceived teacher support, peer support in the class, quality of the context of technology-enhanced learning, academic self-efficacy and student engagement. Cross-sectional surveys designs are commonly used in educational psychology and engagement research to model complex relationships between latent constructs using a statistical method known as structural equation modeling (SEM). Prior research that studies support mechanisms, psychological resourcefulness, and engagement outcomes have made successful use of similar designs Romano et al. (2021), Tang and Wang (2024). The current design is suitable because the study aims to examine theoretically derived causal pathways at risk for enquiry in a mediation framework and less about following developmental change across time. SEM-based cross-sectional investigation is highly accepted and standard as the method to test the integrated psychological models into education set-up Fang et al. (2025), Chen (2025).

3.2. PARTICIPANTS AND SAMPLING

Participants were undergraduate students of engineering courses studying technological programs in the institutions of higher education of India. A total of 423 valid responses were obtained using non-probability purposive sampling. This sampling strategy was chosen because of the target population, which were students actively engaged in technology enhanced learning environments. Purposive sampling is frequently employed in educational research, where access is not possible to a total sampling frame, and where the aim is to include information-rich cases about the research in focus. Comparable studies focusing on the topic of teacher support, and peer dynamics and engagement in classroom contexts have been based on purposive or convenience sampling, and have nevertheless produced robust results for statistical SEM Sullanmaa et al. (2025), Kuokkanen et al. (2024). The sample size is large enough compared to recommended values for CB-SEM mediation models to provide ample statistical power for model estimation, and evaluation of model fit.

3.3. DATA COLLECTION PROCEDURE

Data was collected from a structured online questionnaire through institutional communication channels and classroom networks. Participation was voluntary and respondents were told the academic purpose of the study. To reduce the social desirability effect, anonymity and confidentiality were guaranteed. Students completed the questionnaire during the time of the academic semester and were engaged in technology-enhanced coursework. These timings were to ensure that the perceptions about teacher support, peer interactions and digital learning context quality were reflective of ongoing educational experiences. Similar real-time perception-based data collection approaches have been employed in classroom engagement research Wen et al. (2025), Romano et al. (2021).

3.4. MEASURES

All constructs were assessed with multi-item Likert-type scales based on validated instruments from previous research in educational psychology. Items were placed in the context of engineering education and technology-enhanced learning environments. Perceived Teacher Support was Measured using items describing emotional availability, clarity of instruction, and responsiveness. Adapted from the teacher support scales from engagement and well-being studies Tang and Wang (2024), Chen (2025). Peer Support in Class was Measured Based on the Items Measuring Collaboration, Encouragement, and Mutual Academic Assistance between Classmates Sullanmaa et al. (2025), Kuokkanen et al. (2024) Technology Enhanced Learning Context Quality was Evaluated Through Perceptions of Digital Platform Usability, Instructional Synchronous, and Clarity of Technology-Mediated Learning Structures Yang et al. (2025), Liu et al. (2024) Academic Self-Efficacy was Assessed with Items Related to Confidence in Academic Task Handling, Problem Solving Ability, and Persistence in Tough Coursework Fang et al. (2025), Tang and Wang (2024). Operationalization of Student Engagement was done as behavioral, cognitive, and emotional involvement in coursework Hu and Abu (2023), Romano et al. (2021). All the responses were taken on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree).

4. RESULTS

4.1. MEASUREMENT MODEL ASSESSMENT

The measurement model was assessed with confirmatory factor analysis (CFA) in order to confirm the reliability and validity of latent constructs. All standardized factor loadings from all items were above the recommended level of 0.70 which suggests high indicator reliability. Composite reliability (CR) values were found to be between 0.84 and 0.92 which are above the recommended value of 0.70, indicating internal consistency. Average variance extracted (AVE) values were above 0.50 for all of the constructs and provided evidence for convergent validity. Discriminant validity was measured with the help of Fornell-Larcker criterion and HTMT ratios. The square root for AVE for every construct was larger than the correlations between the constructs; HTMT-value were less than 0.85, thus confirming the empirical distinctiveness of the constructs. The overall measurement model showed an acceptable goodness of fit results with CFI = 0.95, TLI = 0.94, RMSEA = 0.045, SRMR = 0.041. These indices show a good model fit that is consistent with the standards of SEM.

4.2. STRUCTURAL MODEL AND HYPOTHESIS TESTING

The structural model was estimated using covariance-based SEM with bootstrapping (5,000 resamples). The model explained:

- 58% of variance in academic self-efficacy
- 63% of variance in student engagement

Table 1

Table 1 Hypothesis Testing Results

Hypothesis	Path	β	t-value	p-value	Result
H1	Teacher Support → Self-Efficacy	0.42	8.11	<.001	Supported
H2	Peer Support → Self-Efficacy	0.29	5.74	<.001	Supported
H3	Tech Context → Self-Efficacy	0.33	6.02	<.001	Supported
H4	Self-Efficacy → Engagement	0.48	9.20	<.001	Supported
H5	Teacher Support → Engagement	0.21	4.18	<.001	Supported
H6	Peer Support → Engagement	0.17	3.62	<.001	Supported
H7	Tech Context → Engagement	0.19	3.95	<.001	Supported
H8a	Teacher Support → Self-Efficacy → Engagement	Indirect	—	<.001	Supported
H8b	Peer Support → Self-Efficacy → Engagement	Indirect	—	<.001	Supported
H8c	Tech Context → Self-Efficacy → Engagement	Indirect	—	<.001	Supported

All direct paths were significantly positive and in the direction expected. Perceived support from teachers provided significant positive impact on academic self-efficacy, which supports the suggestion that positive instructional relationships help to reinforce students competence beliefs. This is consistent with previous research, showing that the effects of teacher support on psychological resources that motivate engagement Fang et al. (2025), Tang and Wang

(2024). Peer support also had a significant predictive association on academic self-efficaciousness and helped affirm the notion that a collaborative classroom climate reinforces the development of confidence due to shared experiences of mastery Sullanmaa et al. (2025), Wen et al. (2025). Technology enhanced learning context quality showed positively depended on academic self-efficacy outcomes which may suggest well-designed digital learning environment reduces uncertainness and protect competence Chen (2025), Liu et al. (2024). Academic self-efficacy had a significant positive impact on engagement, confirming its main role as a motivational engine of active learning Romano et al. (2021). Direct routes from teacher support or peer support and quality of context to engagement were also significant, suggesting at least some mediation.

4.3. MEDIATION ANALYSIS

Bootstrapped indirect effects were used to confirm that academic self-efficacy significantly mediated all three of the support-engagement relationships. Confidence intervals were not close to zero, providing evidence for the mediation hypotheses. These findings add support to psychological models which argue that supportive environments act through the impact of internal competence beliefs on engagement. The findings extend previous evidence on mediation to technology-enhanced engineering classrooms Chen (2025), Fang et al. (2025).

5. DISCUSSION AND IMPLICATIONS

5.1. GENERAL DISCUSSION

The present study examined the effect of supportive learning ecosystems on student engagement in technology enhanced engineering education in terms of the mediating effect of academic self-efficacy. The results confirm the understanding that engagement is not a product of instructional design or access to technology but is a result of an interaction of relational support and psychological resources of students. By integrating the elements of teacher support, the element of peer support, and the element of technology enhanced learning with context quality in one structural context, the research adds to our understanding of the many environmental factors that converge to influence engagement.

The strongest predictor of academic self-efficacy and engagement was perceived teacher support. This makes the role of instructors as psychological anchors even more important in learning environments, even for mediating instruction through digital platforms. Supportive teachers that offer emotional reassurance, validation of competency and clarity of expectation, that in turn facilitates students to approach academic challenges with confidence These results align with previous evidence that the support of a teacher is linked to increased engagement through motivational and psychological means Tang and Wang (2024), Romano et al. (2021). Importantly, the present study advances this logic by alignment in the sense of engineering education where technological change is fast and so it proposes that digital innovation should not replace the relational factor in teaching.

Peer support progressed also impinged in increasing academic own self-efficacy. Classrooms that function as cooperative communities encourage community experiences of mastery and academic struggle is normalized eliminating fear of failure. Students with positive peer network embeddings are characterised by higher levels of persistence and adaptive engagement behaviour in line with scientific evidence on the importance of social relatedness in educational functioning Sullanmaa et al. (2025), Wen et al. (2025). One of the conclusions that can be drawn from the findings is that engagement is a social phenomenon as it arises out of collective classroom culture and not simply individual effort.

Technology-enhanced learning in the context of quality also contributed to engagement through self-efficacy either directly or indirectly. This makes that digital environments are psychologically consequential even more. When technology is perceived to be coherent, accessible and pedagogy enacted, then this improves the sense of control and competence of students. On the other hand, ill-structured digital systems may not maintain confidence and participation. The findings build on previous research which have found that technology mediated learning environments impact psychological functioning and engagement Chen (2025), Yang et al. (2025), Liu et al. (2024). Engineering education, in particular, being so reliant on digital tools, must in turn place great focus on user-centered design and instructional alignment.

The mediating function of the academic self-efficacy confirms that engagement is not due only to the external support, but to student's internalized beliefs about the capabilities of students. Supportive environments translate into engagement to the extent that students view such environments to signify competence and possibility. This result is consistent with models which point to self-efficacy as an important motivational process between context and behavior Fang et al. (2025), Tang and Wang (2024). The integrated model demonstrates the integrated work of teacher support, peer support and quality of digital context through self-efficacy to stay engaged.

5.2. THEORETICAL IMPLICATIONS

The study contributes to the field of educational psychology in that it combines the relational and technological aspects of learning in a unified viewer of engagement. Much previous research has studied either teacher support or peer support or digital context, or at least some aspect of each, in isolation. By aggregating these factors and using school engagement self-efficacy as a key mediator, the study provides a more holistic explanation of engagement processes.

First, the findings continue to extend support-engagement theory to technology-enhanced higher education contexts. Previous engagement models have been mostly developed in traditional classroom settings Romano et al. (2021). Proving the mechanisms of psychological involvement similarly in digital engineering environments provides support to the robustness of psychological involvement theory.

Second, the study promotes social-cognitive views by demonstrating the convergence of multiple environmental supports through a shared psychological pathway. Rather than acting independently, teacher, peer, and contextual supports act jointly in influencing competence beliefs. This supports ecological models of learning that think of engagement as arising from nested social systems.

Third, the results point out the psychological aspect of the educational technology. Digital learning should not be conceptualized as an infrastructural thing but as an experiential environment that defines self-beliefs and participation. This is a reframing that is a bridge between educational psychology and learning technology research.

5.3. PRACTICAL IMPLICATIONS

The findings have important implications for education institution leaders, engineering educators, and leaders.

Faculty Development

Related to this, the training programs for teachers must be oriented towards a pedagogy of relationships as well as a technological competence. Instructors who communicate care, responsiveness and encouragement reinforce student's psychological readiness to engage. Faculty workshops should provide possibilities for providing emotional support in digital and hybrid classrooms.

Peer Learning Design

Curricula should assist to deliberately produce collaborative learning structures. Group projects, peer mentoring and cooperative problem-solving can be used to help build peer support networks to improve self-efficacy and engagement.

Design and Implementation of Technology

Institutions should not measure the functionality of digital learning systems, but also the psychological ease-of-use. Platforms should be simple and structured and should be linked to pedagogical objectives. Student Feedback should drive digital system improvement to ensure that the technology is working to increase, rather than disrupt learning confidence.

Student Support Programs

Academic support centers should feature self-efficacy building intervention elements, such as mastery experiences, guided reflection, and scaffolded learning paths. The strengthening of beliefs of competence may be as important as the presentation of academic contents.

6. LIMITATIONS, FUTURE SCOPE, AND CONCLUSION

While the current research offers some salient information about involvement in technology-based engineering education, there are several limitations that need to be recognized. First, the cross-sectional design restricts the use of causal inference. Although it is possible to make tests based on theories attempting to indicate directional relationships using SEM, longitudinal or experimental designs would provide better indications for temporal causality. Prior research has shown that engagement and psychological resources develop Upadyaya and Salmela (2013), and therefore, it is proposed that future research adopts a more longitudinal tracking approach to avoid capturing more developmentally. Second, the use of survey data that relies on self-report data is accompanied with the opportunity of common method bias and effects of subjective perception. While some procedural safeguards were put into place, future studies could cross-cut measures of behavioural engagement, learning analytics or teacher assessments to triangulate data. Third, purposive sampling strategy is a concern in terms of the idea of generalization to students outside of the engineering discipline and those who study technology-intensive context. Generalising the model to other disciplines, types of institutions or cultural contexts would increase external validity. Comparative cross-national research may also be a way to further detail the role played by contextual and cultural factors on mechanisms of support engagement.

Future research should take into account other psychological mediators as well as boundary conditions. Constructs such as resilience, motivational quality or psychological safety may work in conjunction with self-efficacy towards engagement. Moreover, qualitative studies could provide a greater understanding of student meaning making of support at digital environments. Experimental innovations that alter teaching support strategies or the design of digital platforms would also be useful in identifying causal mechanisms and feasible instructional practices. As educational technology is evolving, the study of new AI-based systems of learning and its consequences for psychology of learning is a fruitful area for academic research.

In conclusion, this study reveals that technology-based engineering education student engagement is a product of a positive ecosystem where support from teachers, peer cooperation, and digital learning contexts quality work to reinforce academic SE. The engagement is sustained through students internalizing support from the environment in the form of feelings of personal competence. The results suggest the consideration and importance of not only technical innovation, but the integration of psychological principles for the implementation of human-centered instruction design. By framing academic self-efficacy as the bridge between environment and engagement, the study makes a contribution to a more well-integrated understanding of the relationship between relational and contextual supports in learning in modern higher education.

REFERENCES

Chen, S. (2025). Perceived Teacher Support on International Students' Engagement and Psychological Well-Being in Ai-Based Learning: The Mediating Role of Motivation Through the Lens of Self-Determination Theory. Learning and Motivation, 91, 102165. https://doi.org/10.1016/j.lmot.2025.102165

Fang, D., Zhao, S., and Wei, W. (2025). On the Role of Perceived Teacher Support in Predicting EFL Learner Well-Being in Artificial Intelligence (AI)-Based Context: The Mediating Roles of Self-Efficacy and Resilience. European Journal of Education, 60(4), e70242. https://doi.org/10.1111/ejed.70242

Hu, Y., and Abu Talib, M. B. (2023). Student Engagement and its Association with Peer Relation and Teacher-Student Relation: A Systematic Review. Educational Administration: Theory and Practice, 29(4), 35–49. https://doi.org/10.52152/kuey.v29i4.763

Kuokkanen, J., Romar, J.-E., and Hirvensalo, M. (2024). Social Support, Engagement, and Burnout: A Comparative Analysis of Student Athletes and Regular Students in Finnish Lower Secondary Schools. SAGE Open, 14(2). https://doi.org/10.1177/21582440241256224

Liu, J., Dellova, R. I., and Yi, Z. (2024). Digital Learning Environments and Outcomes. E-Learning and Digital Media.

Romano, L., Angelini, G., Consiglio, P., and Fiorilli, C. (2021). Academic Resilience and Engagement in High School Students: The Mediating Role of Perceived Teacher Emotional Support. European Journal of Investigation in Health, Psychology and Education, 11(2), 334–344. https://doi.org/10.3390/ejihpe11020025

Sullanmaa, J., Tikkanen, L., Ulmanen, S., and Pyhältö, K. (2025). Life Satisfaction, Relatedness, and Study Engagement in the Upper Secondary School Transition: The Function of Social Support. Social Psychology of Education, 28(1). https://doi.org/10.1007/s11218-025-10081-1

Tang, C.-W., and Wang, L.-C. (2024). Effect of Perceived Teacher Support on Senior High School Students' Engagement in the Academic Portfolio: Mediating Roles of Anxiety and Self-Efficacy. Journal of Research in Education Sciences, 69(3), 99–137. https://doi.org/10.6209/JORIES.202409_69(3).0004

Upadyaya, K., and Salmela-Aro, K. (2013). Development of School Engagement in Association with Academic Success and Well-Being in Varying Social Contexts: A Review of Empirical Research. European Psychologist, 18(2), 136–147. https://doi.org/10.1027/1016-9040/a000143

Wen, X., Chong, Z. Y., de Alwis, J., Liu, X., and Xu, W. (2025). Daily Relationships Between Elementary School Students' Perceived Teacher/Peer Support and School Behaviors: The Mediating Role of Negative Emotions and the Moderating Role of Mindfulness. Children and Youth Services Review, 176, 108408. https://doi.org/10.1016/j.childyouth.2025.108408

Yang, M., Wu, X., and Deris, F. D. (2025). AI-Assisted Learning and Psychological Functioning. British Educational Research Journal. https://doi.org/10.1002/berj.4184