INTERNATIONAL JOURNAL OF RESEARCH AND INNOVATION IN SOCIAL SCIENCE (IJRISS)
ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VIII August 2026

Transforming Mathematics Education Through Self-Directed and Peer Learning

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DOI: https://doi.org/10.47772/IJRISS.2026.100800330

Received: 13 August 2026; Accepted: 18 August 2026; Published: 03 September 2026

ABSTRACT

The increasing demand for learner autonomy, collaboration, and higher-order thinking requires mathematics education to move beyond conventional lecturer-centered instruction. This study examined a student-centered transformative teaching approach integrating self-directed and peer learning to enhance students' engagement, mathematical understanding, and active participation. A pre-experimental one-group pre-test and post-test design was employed, complemented by a student perception survey and qualitative feedback. The intervention involved self-directed exploration of mathematical topics, expert-group collaboration, development of learning materials and quizzes, Gallery Walk activities, peer sharing, and assessment and reflection. Digital tools were incorporated as supporting mechanisms to facilitate knowledge exploration, creation, and exchange rather than as an independent pedagogical approach. A total of 55 students completed a 14-item questionnaire assessing Self-Directed Learning, Peer and Collaborative Learning, Digital Tools as Learning Support, and Student Satisfaction. The questionnaire demonstrated excellent overall internal consistency (Cronbach's $\alpha = 0.932$). Students' cognitive achievement improved following the intervention, with the mean score increasing from 6.88 ($SD = 3.04$) in the pre-test to 8.76 ($SD = 1.28$) in the post-test. Students also reported highly positive perceptions of the approach, with all questionnaire items recording mean scores between 4.45 and 4.77. Students valued opportunities for self-directed learning, responsibility for their own learning, collaborative knowledge construction, and technology-supported activities. Qualitative feedback further highlighted peer interaction, knowledge sharing, improved understanding, and active participation as important features of the learning experience. Overall, the findings suggest that integrating self-directed and peer learning can provide a supportive environment for promoting learner autonomy, collaboration, engagement, and mathematical understanding. Moreover, given the absence of a control group, further studies using comparative designs and larger samples are recommended as preliminary evidence.

Keywords: collaborative; mathematics education; peer learning; self-directed; student-centered learning

INTRODUCTION

Effective mathematics learning requires students to develop a strong conceptual understanding and the ability to solve problems independently. Traditionally, mathematics teaching has often relied on lecturers as the main source of guidance. However, the Malaysia Education Blueprint 2015–2025 (Higher Education) highlights the need to develop 21st-century skills, including critical thinking, communication, collaboration, and creativity [1]. This shift encourages a more participatory learning approach where students actively engage, interact, and construct their own understanding through meaningful learning experiences. The advancement of technology has further transformed mathematics education by changing how students learn and interact with mathematical concepts [2, 3]. Nevertheless, the key challenge remains in selecting appropriate approaches and tools that enhance teaching effectiveness while preserving the fundamental values of meaningful learning, as highlighted by the Organisation for Economic Co-operation and Development: Educational Research and Innovation 2017 [4].

Self-directed learning empowers students to become the architects of their own learning, fostering the autonomy and critical thinking skills necessary to navigate the complexities of 21st-century engineering [5, 6]. Alongside the growing emphasis on self-determined learning, peer learning has also gained recognition as an important element in developing students' mathematical understanding. Instead of learning mathematics as an individual activity, students can learn more effectively through interaction with their peers, where they have opportunities to explain their ideas, discuss different approaches, and refine their understanding of mathematical concepts [7, 8].

Effective mathematics education requires instructional approaches that move beyond traditional knowledge transmission towards active and meaningful learning experiences. Integrating self-determined learning with peer collaboration can therefore create a more supportive and engaging learning environment, helping to address common challenges in mathematics education, including mathematics anxiety and feelings of isolation among learners [9]. The integration of self-directed, peer, and collaborative learning provides a student-centered approach that promotes autonomy, knowledge sharing, and active engagement in mathematics learning [10]. Self-directed learning encourages students to take ownership of their learning by setting goals and determining their learning strategies, while peer and collaborative learning emphasise interaction, cooperation, and the co-construction of knowledge among learners. Together, these approaches create a supportive learning environment where students become active participants, develop deeper understanding, and enhance their problem-solving and communication skills [10, 11].

The proposed conceptual mathematics education framework, illustrated in Figure 1, positions student-centred learning as the foundation of the transformative teaching approach by integrating self-directed learning with peer and collaborative learning. Guided by heutagogical principles, students take greater responsibility for their learning through independent exploration and reflection, while expert-group collaboration, peer sharing, and discussion enable them to construct and exchange knowledge with others. Digital tools function as enabling mechanisms that support information exploration, content creation, communication, and assessment rather than as a separate pedagogical approach. Assessment and reflection further allow students to monitor and improve their understanding. Collectively, these interconnected elements shift students from passive recipients to active participants in the learning process to enhance student engagement, higher-order thinking, collaboration, and academic performance.

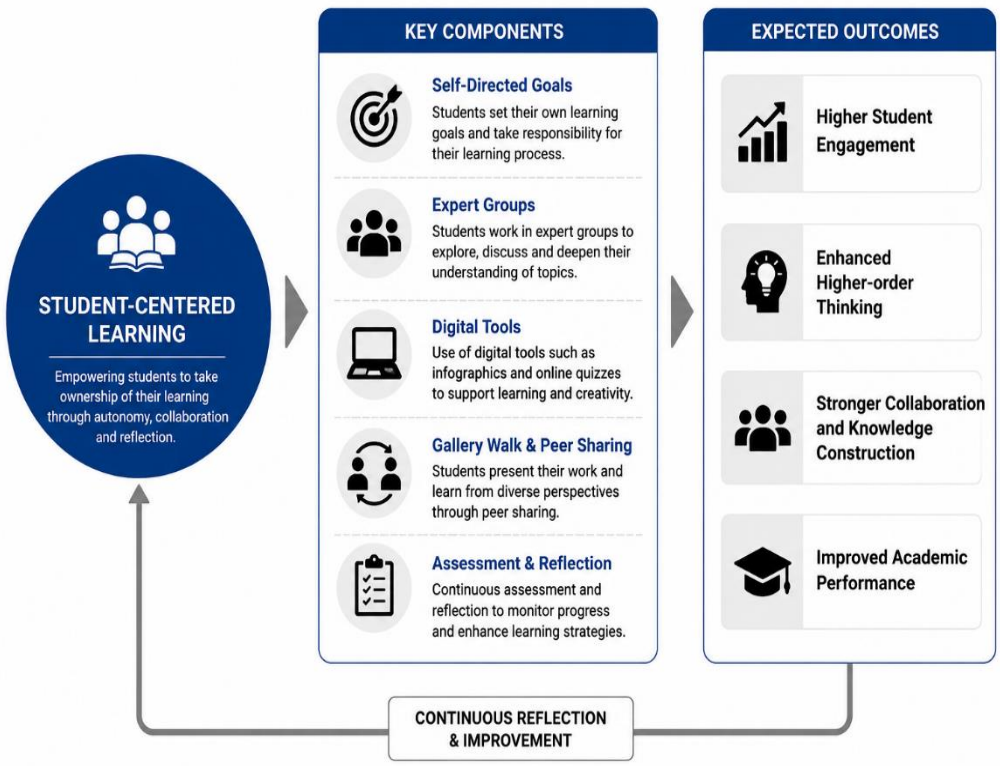

Figure 1. Conceptual Framework of the Student-Centered Transformative Teaching Approach

METHODOLOGY

Research Design

This study employed a mixed-methods intervention design to evaluate the effectiveness of a transformative, student-centred teaching approach in enhancing students' mathematical achievement and learning experiences. The intervention was designed by integrating self-directed, peer, and collaborative learning principles. The approach aimed to shift students from passive recipients of mathematical knowledge towards active participants who construct, share, and apply mathematical understanding through collaborative activities.

The participants consisted of 55 undergraduate students enrolled in the Bachelor of Electrical Engineering (BELG) programme at Universiti Teknikal Malaysia Melaka (UTeM). The intervention was conducted as part of the Engineering Mathematics course during the teaching of the Partial Derivatives topic.

The intervention was conducted over seven contact hours of face-to-face instruction, supported by asynchronous collaborative activities. It was structured around three main stages: (i) collaborative specialization through expert groups, (ii) peer knowledge exchange through Gallery Walk activities, and (iii) reciprocal assessment through student-generated learning materials and quizzes. The learning activities were designed to support students in connecting mathematical concepts with applications while developing collaborative and problem-solving skills. Table 1 explains how the learning activities integrate self-directed, peer, and collaborative learning within the innovative teaching framework and 21st-century skills.

Figure 2 shows the implementation flow of the Student-Centered Teaching approach. The implementation consisted of three sequential phases, as follows;

Phase I: Collaborative through Expert Groups

Students were organised into small expert groups, with each group assigned a specific engineering application related to partial derivatives. Within their groups, students independently explored relevant mathematical concepts, identified real-world engineering problems, and synthesised information from various learning resources. The groups then developed learning materials, including infographics and student-generated quizzes, to communicate their understanding (see flow 1 – 4 in Figure 2). Digital technology was incorporated as an enabling tool throughout the learning activities. Students used digital resources to explore mathematical applications, create learning materials such as infographics and short videos or animations, and develop interactive quizzes for peer assessment.

Phase II: Peer Knowledge Exchange through Gallery Walk

Following the development of learning materials, students participated in a Gallery Walk activity, during which each expert group presented their work to their peers (refer to flow 5 and flow 6 in Figure 2). During this session, students acted as both learners and facilitators by explaining concepts, responding to questions, and discussing alternative approaches to solving engineering mathematics problems.

Phase III: Reciprocal Assessment and Reflection

The final phase involved student-designed quizzes and reflective activities (refer to flow 6 in Figure 2). Each group developed assessment questions based on their assigned topic, which were then completed by their peers. This process encouraged students to consider common misconceptions, evaluate their peers' understanding, and refine their own mathematical reasoning.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VIII August 2026

Table 1: Integration of Self-directed, Peer, and Collaborative Learning in the innovative teaching Framework

Learning Activity	Pedagogical Principle	21st-Century Skills
Form groups of up to five students. Select and explore a partial derivative application and its real-life uses.	Peer: collaborative learning, co-learning Self-directed: learner choice	Teamwork, collaboration Critical thinking, problem-solving, decision-making
Design an infographic on the selected application.	Self-directed: learner autonomy; Peer: co-creation	Creativity, digital literacy, communication
Develop a quiz based on the application.	Learner-generated assessment; co-creation	Critical thinking, digital skills
Share findings with peers.	Peer knowledge sharing	Communication, collaboration
Present and facilitate peer learning using the developed quiz.	Learner-led teaching; peer assessment	Presentation, communication, collaboration

Note: Pedagogical principles and skills were informed by recent literature on self-determined and collaborative learning [18, 19] and higher-order thinking skills [20].

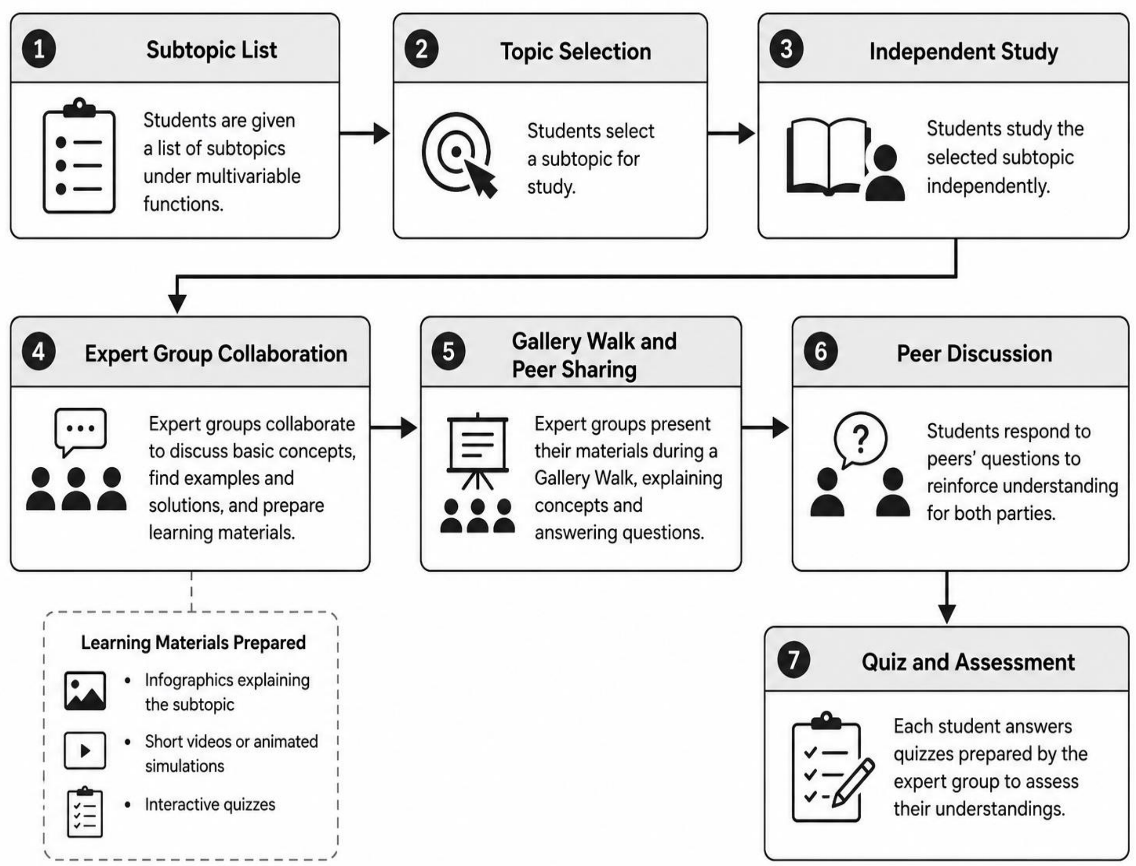

Figure 2. Implementation Flow of the Student-Centered Transformative Teaching Approach

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II. Data Collection and Analysis

Data were collected at two stages of the intervention. Quantitative data on students' cognitive achievement were obtained through the pre-test and post-test. The pre-test and post-test scores were analysed using descriptive statistics to examine changes in students' cognitive achievement following the intervention. Mean scores and standard deviations (SD) were used to compare students' performance before and after the implementation of the transformative teaching method. A paired-samples t-test was conducted to determine whether the difference between pre-test and post-test scores was statistically significant. Cohen's d was also calculated to estimate the magnitude of the observed change. The magnitude of improvement between the two assessments was also examined to evaluate the educational impact of the intervention.

Upon completion of the learning activities, a student perception survey was conducted to evaluate students' experiences with the teaching method (see Appendix A). The questionnaire comprised 14 items measured using a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The instrument focused primarily on two pedagogical dimensions: Self-Directed Learning and Peer and Collaborative Learning. The Peer and Collaborative Learning dimension comprised four items assessing peer interaction, individual contribution, knowledge sharing, and collaborative learning. The items were informed by established cooperative learning constructs, including positive interdependence, individual accountability, promotive interaction, and active participation [19].

Three additional items assessed the perceived usefulness of digital tools as learning support**,** including students' enjoyment of using technology and their perceptions of the extent to which digital tools facilitated the learning process and supported their understanding of the required knowledge. In this study, digital technology was used as a mechanism that supported self-directed and collaborative learning rather than as an independent pedagogical dimension. The remaining three items assessed students' overall learning experience and satisfaction.

The questionnaire was adapted and contextualised from established and recently validated instruments and constructs related to self-directed learning by the Self-Directed Learning Readiness Scale (SDLRS) [12, 13], peer and collaborative learning [14], perceived usefulness of digital technology [15], and student learning satisfaction [16]. The items were modified to reflect the specific context and learning activities implemented in the present study. The internal consistency of the questionnaire was assessed using Cronbach's alpha (α) for the overall instrument and for each component separately. A coefficient of 0.70 or above was considered indicative of acceptable internal consistency.

In addition to the questionnaire, open-ended comments were collected to obtain further insight into students' experiences during the intervention. The responses were reviewed and grouped according to recurring ideas related to peer interaction, conceptual understanding, knowledge sharing, and active participation. The responses were used as supplementary qualitative evidence to provide context for the quantitative findings rather than as a standalone thematic analysis. Representative comments were included to illustrate the recurring patterns identified in the responses.

RESULTS & DISCUSSION

The reliability analysis indicated satisfactory internal consistency across all questionnaire components. The overall instrument demonstrated excellent reliability ($\alpha = 0.932$). At the dimensional level, Cronbach's alpha coefficients ranged from 0.710 to 0.939, with self-directed learning ($\alpha = 0.767$), peer and collaborative learning ($\alpha = 0.847$), and Student Satisfaction ($\alpha = 0.710$) demonstrating acceptable to good internal consistency. In contrast, the perceived usefulness of digital tools demonstrated excellent reliability ($\alpha = 0.939$). These findings indicate that the questionnaire items within each dimension consistently measured their respective constructs.

. Analysis of Student Academic Performance

Students' cognitive achievement was evaluated by comparing their performance before and after the implementation of the transformative teaching method. A paired-samples t-test was conducted to examine differences in students' performance before and after the intervention. The results showed that the mean post-test score ($M = 8.84$, $SD = 1.32$) was higher than the mean pre-test score ($M = 7.09$, $SD = 2.87$), representing an improvement of 1.75 points. This improvement was statistically significant, $t(54) = 3.53, p = .001$, with a moderate effect size (Cohen's $d_z = 0.61$). The lower standard deviation in the post-test also indicates that students' scores were more consistent following the intervention. Overall, the findings demonstrate a significant and meaningful improvement in students' performance after the intervention.

Table 2. Comparison of Pre-Test and Post-Test Performance

Assessment	Mean	SD	Mean Improvement
Pre-test	7.09	2.87	–
Post-test	8.84	1.32	+1.75

The higher mean score in the post-test suggests that students developed a better understanding of the mathematical concepts after participating in the transformative learning activities. At the same time, the decrease in standard deviation from 2.87 to 1.32 shows that students' post-test scores were more closely grouped. This suggests that the activities may have supported not only overall improvement but also a more consistent level of understanding across the students.

The observed improvement can be associated with the learning process. Rather than receiving mathematical concepts primarily through lecturer-directed instruction, students selected topics, independently explored applications, developed learning materials and quizzes, and subsequently explained their knowledge to their peers. Such activities required students to take greater responsibility for acquiring and communicating mathematical knowledge. The peer-sharing process further provided opportunities for students to clarify concepts through explanation, questioning, and discussion. This interpretation is consistent with evidence supporting active and peer-based learning in higher education and STEM contexts [17].

Nevertheless, as the study used a one-group pre-test–post-test design without a control group, the observed improvement cannot be attributed solely to the intervention. The findings should therefore be interpreted as evidence of positive change following the teaching approach, rather than as conclusive evidence for testing, maturation, or other external influences. Future studies could employ a control or comparison group, staggered implementation, or a Solomon four-group design to provide stronger evidence of intervention effects and account for possible pre-testing effects. Other than that, future research could examine whether the effectiveness of the approach varies according to students' prior achievement and investigate the potential role of student engagement in explaining changes in learning outcomes.

II. Evaluation of Student Perceptions and Engagement

Overall, students demonstrated positive perceptions of the transformative learning activities. Supported by Table 3, responses were predominantly concentrated in the Agree and Strongly Agree categories across the questionnaire, although several items received Neutral or Disagree responses. This pattern indicates generally favorable experiences while also demonstrating some variation among individual students.

Table 3: Descriptive Statistics of Student Feedback

ELEMENTS	COMPONENTS	M	SD
SELF-DIRECTED LEARNING	The activity stimulated my interest in the subject	4.64	0.48
	The activity encouraged discussions and increased self-learning.	4.77	0.42
	The activity developed the skills to obtain the required knowledge of the topics	4.59	0.49

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VIII August 2026

	I took responsibility for learning what I needed from the activity.	4.73	0.45
PEER AND COLLABORATIVE LEARNING	The activity encouraged peer-to-peer learning.	4.50	0.58
	All team members contributed appropriately to the learning process.	4.45	0.50
	I learned the required knowledge from my team members and other groups.	4.50	0.58
	The activity promoted collaborative learning with other students	4.64	0.48
DIGITAL TOOLS AS LEARNING SUPPORT	I enjoyed using technology for learning	4.73	0.54
	Technology facilitated the learning process	4.73	0.45
	Technology helped me understand the required knowledge	4.64	0.57
STUDENT SATISFACTION	The activity challenged me to do my best work	4.59	0.58
	The activity supported in-depth understanding of the topics	4.73	0.45
	The session was conducted within an appropriate duration	4.50	0.72

*M – Mean; SD – Standard Deviation

A) Self-Directed Learning

Students demonstrated highly positive perceptions of the self-directed aspects of the learning activities, with item means ranging from 4.59 to 4.77. The highest mean was recorded for the statement that the activity encouraged discussion and increased self-learning (M = 4.77, SD = 0.42), followed by students' recognition of their responsibility for determining what they needed to learn (M = 4.73, SD = 0.45). Students also reported that the activity stimulated their interest (M = 4.64, SD = 0.48) and developed their ability to obtain the required knowledge (M = 4.59, SD = 0.49).

These findings suggest that the learning activities successfully encouraged students to assume a more active role in the learning process. The opportunity to select a topic, undertake independent exploration, develop learning materials, and subsequently communicate their understanding to others provided students with greater ownership of their learning. This reflects the principles of self-directed learning, particularly learner responsibility, autonomy, and active knowledge acquisition.

B) Peer and Collaborative Learning

Positive perceptions were also observed for peer and collaborative learning, with mean scores ranging from 4.45 to 4.64. The highest-rated item was the promotion of collaborative learning with other students (M = 4.64, SD = 0.48). Students also agreed that the activity encouraged peer-to-peer learning (M = 4.50, SD = 0.58) and enabled them to acquire knowledge from their own team members and other groups (M = 4.50, SD = 0.58).

The slightly lower mean for team members' contribution (M = 4.45, SD = 0.50) suggests some variation in participation within groups, although students' perceptions remained highly positive. Despite this, the expert-group discussions, peer explanations, and Gallery Walk provided meaningful opportunities for students to exchange ideas, clarify their understanding, and learn from one another, supporting the peer and collaborative learning component of the teaching approach.

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C) Digital Tools as Learning Support

Students also responded favorably to the use of digital technology. Enjoyment of using technology for learning and the perception that technology facilitated the learning process both recorded high mean scores (M = 4.73, SD = 0.54 and M = 4.73, SD = 0.45, respectively). Students similarly agreed that technology helped them understand the required knowledge (M = 4.64, SD = 0.57). These findings support the role of digital technology as an enabling mechanism rather than a separate pedagogical approach. Digital tools facilitated students' independent exploration, preparation of infographics and learning materials, development of interactive quizzes, and sharing of knowledge with peers. Therefore, their educational value was closely connected to how they supported the broader self-directed and collaborative learning processes.

D) Student Satisfaction

Students reported positive overall experiences with the learning activities. The strongest response was obtained for the activity that supported in-depth knowledge of the topics (M = 4.73, SD = 0.45). Students also perceived that the activities challenged them to produce their best work (M = 4.59, SD = 0.58).

The item related to session length and duration received a slightly lower mean and showed the greatest variation in responses (M = 4.50, SD = 0.72). While students generally felt that the time allocated was appropriate, the wider spread of responses suggests that some may have needed more time for independent exploration, preparation, and peer sharing. Providing greater flexibility in the timing of these activities could therefore improve future implementation. Overall, students responded very positively to the teaching approach, with all 14 items achieving mean scores of 4.45 or higher. They particularly valued opportunities for self-directed learning (M = 4.77), taking responsibility for their own learning (M = 4.73), using technology to support the learning process (M = 4.73), and developing a deeper understanding of the topics (M = 4.73). These positive perceptions were accompanied by an increase in achievement from the pre-test (M = 6.88, SD = 3.04) to the post-test (M = 8.76, SD = 1.28). Together, the findings suggest that the approach created a supportive environment for learner autonomy, peer collaboration, active participation, and mathematical understanding, although the lack of a control group means that the improvement cannot be attributed solely to the intervention.

Students' qualitative feedback further supported the quantitative findings. The comments indicated four recurring aspects of the learning experience: peer interaction and collaboration, improved understanding and problem-solving, knowledge sharing through peer teaching, and active and enjoyable learning as shown in Table 4. Students particularly value being able to discuss difficulties directly with peers, exchange knowledge across groups, and explain mathematical concepts to others. Several comments also suggested that the interactive nature of the activities created a more engaging learning environment. These observations complement the high ratings for collaborative learning and suggest that peer interaction served not only as a means of knowledge sharing but also as a mechanism for clarifying mathematical understanding and encouraging active participation.

Table 4. Students' Reflections on Their Transformative Learning Experience

Item	Representative Student Feedback	Interpretation
Peer interaction and collaboration	"Ask directly to our friends"; "Group discussion and learning from session to another session"; "Casual learning session with colleagues"	Students valued opportunities to discuss, interact, and learn collaboratively with peers.
Improved understanding and problem-solving	"We can focus on one topic at a time and understand the topic more"; "We can discuss the confusion when we did not get the correct answer."	Peer discussion helped students clarify difficult concepts and resolve mathematical problems.

Knowledge sharing and peer teaching	"The activity boosts my knowledge more and I learn how to teach another person on certain topics."	Students developed understanding by both receiving and communicating knowledge.
Active and enjoyable learning	"All students interact with each other"; "Prevents us from being sleepy in class"; "We can learn and respond to the questions joyfully."	Interactive activities encouraged participation and created a more engaging learning environment.

The findings also highlight several practical considerations for implementation. Clear roles and responsibilities should be established within expert groups to encourage balanced participation and individual accountability. Adequate and flexible time should be allocated for independent exploration, preparation, peer sharing, and assessment. Instructors should also provide clear task instructions and assessment criteria while maintaining sufficient flexibility for students to take responsibility for their learning.

Despite the promising findings, research on self-directed and peer-learning approaches remains relatively limited in higher-level Engineering Mathematics, particularly for multivariable calculus topics. Furthermore, the long-term impact of these approaches on students' professional competencies after graduation remains underexplored. Future studies could therefore use longitudinal designs to examine whether the benefits of self-directed and collaborative learning are sustained over time, while also developing assessment methods that capture both learning competencies and mathematical achievement.

CONCLUSION

This study demonstrates the potential of a transformative teaching method integrating self-directed and peer learning to enhance the learning of Engineering Mathematics. The improvement observed between the pre-test and post-test suggests positive development in students' mathematical understanding, while the perception survey indicates strong engagement in self-directed and collaborative learning, supported by digital tools as an enabling mechanism. By allowing students to explore mathematical applications independently, create learning materials, exchange knowledge, and teach their peers, the approach shifted learning from a predominantly lecturer-centered process towards greater learner autonomy, active participation, and shared knowledge construction. These experiences are particularly relevant to engineering education, where problem-solving, teamwork, adaptability, communication, and lifelong learning are essential professional competencies. Although the findings are encouraging, the pre-experimental design and absence of a control group limit causal interpretation; therefore, future studies involving larger samples, comparison groups, and longitudinal evaluation are recommended to establish the broader and sustained effectiveness of the approach.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge Universiti Teknikal Malaysia Melaka (UTeM) for its support in facilitating this study.

REFERENCES

1. Ministry of Education Malaysia. (2015). Malaysia Education Blueprint 2015-2025 (Higher Education). Ministry of Education Malaysia.
2. Simsek, A., Clark-Wilson, A., Bretscher, N., & Hoyles, C. (2026). Exploring mathematics teachers' integration of technology into classroom teaching practice: a focus on geometric similarity. International Journal of Mathematical Education in Science and Technology, 57(4), 697–727.
3. https://doi.org/10.1080/0020739X.2025.2469865
4. Engelbrecht, J., Borba, M.C. Recent developments in using digital technology in mathematics education. ZDM Mathematics Education **56**, 281–292 (2024). https://doi.org/10.1007/s11858-023-01530-2

5. OECD (2017), The OECD Handbook for Innovative Learning Environments, OECD, Publishing, Paris, http://dx.doi.org/9789264277274-en.
6. Nabovati, H. (2024). Developing and Assessing Lifelong Learning Skills through a Self-Determined Learning Approach. https://doi.org/10.24908/pceea.2024.18519
7. Darade, P. D., Jolhe, P. D., Patil, V., Chougule, M. N., & Kubde, R. R. (2024). Pedagogy To Heutagogy: Empowering Engineering Students For 21st -Century Challenges. International Journal on Environmental Sciences. https://doi.org/10.64252/320f8v02
8. Michael, Batsa & Arthur, Yarhands & Asare, Bright. (2025). Influence of peer learning, self-regulatory learning, and mathematics interest on mathematics performance. 2. 3047-9207.
9. Oikarinen, R.M., Oikarinen, J.K., Havu-Nuutinen, S. et al. Students' collaboration in technology-enhanced reciprocal peer tutoring as an approach towards learning mathematics. Educ Inf Technol 27, 7519–7548 (2022). https://doi.org/10.1007/s10639-021-10799-3
10. D'Souza, S., Wood, L. N. (2003). Rationale for collaborative learning in first year engineering mathematics. https://opus.lib.uts.edu.au/bitstream/10453/5661/1/2003001066.pdf
11. Gürbüz MÇ, Özkul R and Şen S (2026) The relationship between peer learning and self-directed learning: the mediating role of collaborative leadership among pre-service mathematics teachers. Front. Psychol. 16:1724725. https://doi:10.3389/fpsyg.2025.1724725
12. Bhardwaj V, Zhang S, Tan YQ and Pandey V (2025) Redefining learning: student-centered strategies for academic and personal growth. Front. Educ. 10:1518602. https://doi:10.3389/feduc.2025.1518602
13. Fisher M, King J, Tague G. Development of a self-directed learning readiness scale for nursing education. Nurse Educ Today. 2001 Oct;21(7):516-25. https://doi.org/10.1054/nedt.2001.0589
14. Chen SL, Fan JY. Validation of the psychometric properties of the Self-Directed Learning Readiness Scale. Nurs Open. 2023 Mar;10(3):1639-1646.
15. https://doi.org/10.1002/nop2.1418
16. Kiper, A. (2016). The validity and reliability of the Turkish version of the Collabrative Learning Scale. International Journal of Educational Research Review, 1(2), 42–48. https://doi.org/10.24331/ijere.309966
17. Balaman, F., & Baş, M. (2023). Perception of using e-learning platforms in the scope of the technology acceptance model (TAM): a scale development study. Interactive Learning Environments, 31(8), 5395–5419. https://doi.org/10.1080/10494820.2021.2007136
18. Topala, I., & Tomozii, S. (2014). Learning satisfaction: Validity and reliability testing for Students' Learning Satisfaction Questionnaire (SLSQ). Procedia - Social and Behavioral Sciences, 128, 380–386. https://doi.org/10.1016/j.sbspro.2014.03.175
19. Gao, H., Evans, T., & Fergusson, A. (2025). Student-generated explanation in undergraduate mathematics and statistics education: a systematic literature review. International Journal of Mathematical Education in Science and Technology, 56(12), 2534–2557. https://doi.org/10.1080/0020739X.2025.2556867
20. Ramas, S., Yasin, R. M., & Adnan, N. H. (2024). Benefits and challenges of the heutagogy approach in education: A systematic review. Cypriot Journal of Educational Sciences, 19(2). https://10.18844/cjes.v19i2.7604
21. Silva, H., Lopes, J. P., Cecchini, J. A., Fernández-Rio, J., et al. (2024). Cooperative learning scale: Validation among Portuguese and Brazilian university students. Revista Brasileira de Educação, 29. https://doi.org/10.1590/S1413-24782024290014
22. Hague, C. (2024). Fostering higher-order thinking skills online in higher education: A scoping review. OECD Education Working Papers, No. 306. OECD Publishing. https://doi.org/10.1787/84f7756a-en

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VIII August 2026

APPENDIX A

Student Perception Questionnaire

Transformative Student-Centred Mathematics Learning Activities

Purpose. This questionnaire aims to gather students' perceptions of the learning activities, with emphasis on self-directed learning, peer and collaborative learning, digital tools as learning support, and overall learning experience.

Instructions. Please indicate the extent to which you agree with each statement using the scale below. Responses are anonymous and will be used for research and educational improvement purposes.

1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
Select one response for each statement.				

A. Self-Directed Learning

No.	Statement	1	2	3	4	5
1	The activity stimulates my interest in the subject.	☐	☐	☐	☐	☐
2	The activity encourages discussion and self-directed learning.	☐	☐	☐	☐	☐
3	The activity develops my ability to obtain the knowledge required for the topic.	☐	☐	☐	☐	☐
4	I take responsibility for learning what I need to know from the course activity.	☐	☐	☐	☐	☐

B. Peer and Collaborative Learning

No.	Statement	1	2	3	4	5
5	The activity encourages peer-to-peer learning.	☐	☐	☐	☐	☐
6	All students in the team contribute appropriately to the learning process.	☐	☐	☐	☐	☐
7	I am able to learn the required knowledge from my team members and other groups.	☐	☐	☐	☐	☐
8	The activity promotes collaborative learning with other students.	☐	☐	☐	☐	☐

C. Digital Tools as Learning Support

No.	Statement	1	2	3	4	5
9	I enjoy using technology for learning.	☐	☐	☐	☐	☐

10	I believe that the use of technology facilitates the learning process.	☐	☐	☐	☐	☐
11	I believe that technology helps me understand the required knowledge.	☐	☐	☐	☐	☐

D. Student Learning Experience and Satisfaction

No.	Statement	1	2	3	4	5
12	The activity challenges me to do my best work.	☐	☐	☐	☐	☐
13	The activity supports an in-depth understanding of the topics.	☐	☐	☐	☐	☐
14	The session is conducted within an appropriate length of time.	☐	☐	☐	☐	☐

E. Open-Ended Feedback

1. What did you like most about the learning activities?

2. What would you change about the learning activities?

3. What suggestions do you have to improve the learning activities?

Research note: The questionnaire items were adapted and contextualised from established constructs related to self-directed learning, peer and collaborative learning, digital learning support, and student learning satisfaction.