International Journal of Modern Education
IJMOE
EISSN: 2637-0905
Volume: 8 Issue: 31 (September 2026) PP. 2086-2097



INTERNATIONAL JOURNAL OF MODERN EDUCATION (IJMOE)
www.gaexcellence.com/ijmoe

GLOBAL ACADEMIC EXCELLENCE

ENHANCING STUDENT UNDERSTANDING IN STRUCTURAL COURSES THROUGH CONSTRUCTIVIST LEARNING THEORY: A QUALITATIVE CLASSROOM OBSERVATION STUDY

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Article Info:

Article history:
Received date: 27.07.2026
Revised date: 18.08.2026
Accepted date: 24.09.2026
Published date: 30.09.2026

Abstract:

Structural courses are fundamental in engineering and construction education, yet many students struggle to comprehend and understand the concepts and applying theoretical knowledge into real-world scenarios. Deep learning and student engagement are frequently hampered by traditional lecture-based teaching methods. This study aims to evaluate how constructivist learning theory constructs are

International Journal of Modern Education
IJMOE
EISSN: 2637-0905
Volume: 8 Issue: 31 (September 2026) PP. 2086-2097

To cite this document:

Mohammad, W. N. S. W., Ibrahim, M. H. W., Zamri, N. A., Hadzaman, N. A. H., Abdullah, W. N. H. W., & Nhari, R. N. R. (2026). Enhancing Student Understanding in Structural Courses Through Constructivist Learning Theory: A Qualitative Classroom Observation Study. *International Journal of Modern Education, 8*(31), 2086-2097.

manifested in classroom practice through a qualitative classroom observations study. The classroom observations were conducted over a 14-weeks teaching period involving 13 students in a structural courses. Five (5) constructivist learning theory constructs (i.e., Active Learning, Knowledge Construction, Social Interaction, Contextual Relevance and Learner Autonomy) were examined through problem-based learning, group discussions, and the use of visual and interactive teaching aids. The collected data were analysed using deductive thematic analysis that identifies patterns and shifts in responses from the students. The findings revealed that the constructivist learning theory constructs, particularly social interaction, were associated with student to demonstrated greater opportunities to articulate, discuss and apply structural concepts and suggesting the development of conceptual understanding. The study concludes that innovative, student-centred teaching methods are effective in enhancing understanding in structure subjects. The findings provided practical insights for lecturers seeking to improve teaching practices and learning outcomes in construction education. The incorporation of digital technologies to enhance student learning in structural courses may be the subject of future research.

DOI: 10.35631/IJMOE.831121

Keyword:

Structural Courses, Constructivist Learning Theory, Classroom Observation, Qualitative Study, Student Understanding

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Introduction

Structural courses are essential components in construction and building technology education as they provide students with the fundamental knowledge required to understand the behaviour, stability, and safety of structures (Çalışkan & Karakuş, 2023). Theoretical concepts, mathematical procedures, and technical applications (i.e., shear force and bending moment, load transfer, reinforcement design, and structural performance) involve in this course. However, according to Kraus et al., (2022), many students find structural subject challenging due to they need to connect structural theories with practical construction situations. As a result, students' comprehension may remain procedural rather than conceptual if they are unable to see how structural concepts are used in actual building components. In many classroom settings, structural courses are delivered through lecture-based approaches, particularly when introducing theories, design procedures, and calculation methods. As, lectures is important to explain the fundamental concepts and ensuring systematic content delivery, students may face cognitive challenge when they are required to visualise structural behaviour, understand support conditions, interpret load paths, and apply mathematical procedures to practical construction problems.

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Innovative teaching approaches (i.e., group discussion, visual teaching aids, problem-based learning and interactive classroom activities) have been implemented to address the issues and encourage more engaging and learning experiences. These methods promote peer collaboration, active student participation, and discussion of problem-solving techniques as well as the application of structural concepts to the real word situations (Awwad, 2025). In structural courses, problem-based and interactive learning methodologies are allow student to investigate structural problems, test solutions, and build greeter grasp of how structural principles are utilized in the real construction scenarios. Students' understanding in structural courses cannot merely be fully examined through test scores alone. Classroom learning behaviours such as participation, interaction, questioning, confidence, and the ability to connect concepts with real-life situations are also important indicators of understanding (Yusuf et al., 2023). In this study, students' learning behaviours were observed through five classroom observation constructs: active learning, knowledge construction, social interaction, contextual relevance, and learner autonomy. The observation checklist was developed with reference to classroom observation practices in construction-related TVET education, particularly within the context of building technology, and was contextualised for structural courses to capture learning behaviours related to structural problem-solving, visualisation, peer discussion, and practical construction applications.

Although innovative teaching approaches have been increasingly explored in structural education, particularly through active learning and problem-based learning, existing studies mostly focus on students' performance, perceptions, or learning outcomes. However, less attention has been given on how students behave, interact, and demonstrate an understanding during face-to-face structural course activities. This demonstrated a research gap in understanding how creative teaching approaches affect student learning behaviours in classroom environments. Thus, this study aims to evaluate how well cutting-edge innovative teaching approaches enhance students' participation, engagement and conceptual understanding. Specifically, the study looks at how using these approaches improve students' comprehension of important concepts during learning activities (i.e., problem-based learning, group discussion, visual aids, and interactive teaching approaches) may promote active participation, and raises student engagement.

Type of Innovative Teaching Approaches in Education

In engineering and construction education, innovative teaching approaches have gained attention as alternatives to conventional lecture-centred approaches. These approaches seek to encourage active participation, student engagement, and facilitate deeper learning through authentic and collaborative experiences. For instance, Problem-Based Learning (PBL) is among the most widely adopted approaches in engineering education. PBL engages students in solving authentic problems that resemble professional practice, thereby encouraging critical thinking, knowledge integration, and independent learning. Through structured problem-solving activities, students develop both conceptual understanding and practical reasoning skills. Collaborative learning and group discussions also play important roles in enhancing learning outcomes. Students are exposed to multiple perspectives, share problem-solving strategies, and collectively construct knowledge through interaction. Research indicates that collaborative learning environments improve engagement, communication skills, and conceptual understanding in technical disciplines (Awwad, 2025).

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Visual and interactive teaching aids further support learning in structural courses. Technologies such as simulations, physical models, animations, mixed reality environments, and graphical visualisations facilitate students understand complex structural behaviours that may otherwise remain abstract. Kraus et al. (2022) demonstrated that immersive learning technologies can boost student understanding of structural design and verification processes by offering interactive visual representations of engineering concepts. Furthermore, Student-centred learning approaches collectively promote active engagement, deeper conceptual learning, and meaningful participation. These approaches shift the role of students from passive recipients of information to active participants in knowledge creation, making them particularly suitable for structural education.

Theoretical Foundation: Constructivist Learning Theory

This study is grounded in Constructivist Learning Theory, which posits that students actively construct knowledge through experience, reflection, and social interaction rather than passively collecting information from lecturers. Piaget (1972) and Vygotsky (1978) disclosed that, learning occurs when students connect new information with their existing knowledge and interpret meaning from their learning experiences (Piaget, 1972; Vygotsky, 1978). Since students are encouraged to solve problems, apply concepts to practical situations, reflect on their learning, and collaborate with peers, the employment of creative teaching approach in structural courses is consistent with constructivist theory. Five (5) main constructs of Constructivist Learning Theory are as follows:

Active Learning

Active learning involves students actively participating in learning activities rather than simply listening to lectures. Through inquiry, conversation, and problem-solving activities, students become more engaged in the learning process. Is has been demonstrated that active learning enhance student performance, comprehension, and involvement in STEM education (Freeman et al., 2014). In structural courses, it facilitates students analyse structural problems and better understand structural concepts.

Knowledge Construction

Knowledge construction refers to the process of building new understanding by connecting new information with prior knowledge. Students learn more effectively when they actively explore, reflect, and develop their own understanding rather than memorising information (Piaget, 1972). In structural courses, this occurs when students relate theoretical concepts to practical examples and structural problem-solving activities.

Social Interaction

According to Vygotsky (1978), learning is a social process that develops through interaction and collaboration with others. Students can share ideas and learn from various viewpoints through group discussions and cooperative activities, which improves their comprehension of structural concepts.

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Contextual Relevance

Constructivist learning emphasises the importance of connecting learning to real-life situations. Students understand concepts more effectively when they can see their practical application (Jonassen, 1999). In structural courses, contextual relevance is attained by employed of case studies, real-world examples, and construction-related scenarios that helps students in connecting between theory with practice.

Learner Autonomy

Learner autonomy refers to students taking responsibility for their own learning. Students are encouraged to autonomously investigate concepts, make decisions, and control their learning process in constructivist learning environments. Autonomous learners are generally more motivated and engaged in learning activities (Zimmerman, 2002). In structural courses, learner autonomy can be observed when students actively seek solutions and participate independently in learning tasks. Overall, previous studies suggest that innovative and student-centred teaching approaches can enhance students' learning experiences and understanding of structural education. Guided by Constructivist Learning Theory, this study investigates how interactive and student-centred teaching methods enhance students' understanding, engagement, participation, and learning behaviours in structural courses through the qualitative classroom observation.

Research Methodology

Classroom observations were conducted over a period of 14 weeks to examine students' participation, engagement, and conceptual knowledge using cutting-edge teaching approaches. The observations, which include both lecture and tutoring sessions, were conducted in real classrooms. Over the course of 14 weeks, there were two lectures and one tutorial every week, for a total of three hours of classroom observation per week. The innovative teaching approaches were incorporated into both lecture and tutorial sessions. As such, group discussions were conducted to encourage student to compare their response, debate solutions and explain their reasons within peers. While, students were assisted in visualising structural concepts and connecting theoretical concepts to real-world applications through the use of visual teaching aids or other pertinent visual materials. Peer discussion, guided problem-solving, students responses and lecturer questions were all part of the interactive activities. In addition, the lecturer acted as facilitators by offering clarifications, directions and comments when required.

Throughout the teaching session, observations were made to record students' reactions and learning behaviour in various classroom scenarios and activities. Four (4) lecturers participated as observers. During both lecture and tutorial sessions, the lecturer methodically observed and documented students' participation, engagement, interaction, and proof of conceptual knowledge. The observers recorded pertinent classroom behaviours and activities using structure observation notes and predetermined observation indicators aligned with the research objectives.

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The Classroom Observation data were analysed using a deductive thematic analysis approach guided by the Constructivist Learning Theory. Five theoretically derived construct were examined: Active Learning, Knowledge Construction, Social Interaction, Contextual Relevance, and Learner Autonomy. Each construct comprised of five observable indicators that reflected the corresponding constructivist learning practices. Each indicator was assessed using a four-point observation scale, ranging from 4 (Frequently Observed) to 1 (Not Observed). The scale was used to indicate the frequency with which the specified teaching and learning behaviour was demonstrated during the observed lesson. The observation ratings were subsequently examined across the indicators within each construct to identify consistent, moderate, or limited patterns of observed practice.

The analysis focused on synthesising the rating patterns within each predetermined construct rather than interpreting individual indicators in isolation. The observed rating patterns were then used as evidence to support the thematic interpretation of constructivist teaching and learning practices. The findings were reported by presenting the construct, observing the Likert-scale evidence, and corresponding interpretation, allowing the quantitative observation ratings to be meaningfully interpreted within the theoretical framework. This deductive approach is appropriate when predetermined analytical constructs are informed by an established theoretical framework (Braun & Clarke, 2021; Kiger & Varpio, 2020).

Table 1: Likert scale for the assessment of the classroom observation

Rating	Description
4	Frequently Observed – The behaviour or activity was consistently observed during the lesson.
3	Occasionally Observed – The behaviour or activity was observed sometimes during the lesson.
2	Rarely Observed – The behaviour or activity was seldom observed during the lesson.
1	Not Observed – The behaviour or activity was not observed during the lesson.

Thirteen diploma students were selected as participants (i.e., three (3) lecturers observed three (3) students each and one (1) lecturer observed four (4) students) based on the student's involvement in class during learning sessions utilising the cutting-edge teaching approaches. Since, the objective of the qualitative study was to gather detailed observations rather than statistical generalization, the sample size of 13 was deemed adequate (Malterud et al., 2016). Over 14 weeks, the students were frequently observed during both one-hour tutoring sessions and two-hour lectures. This provided sufficient observational data to identify trends in students; participation, engagement, and conceptual comprehension.

Results and Discussion

This section presents the findings from classroom observations conducted by four (4) lecturers with different structural course lessons. Although the lesson topics may differ across observers, the same observation checklist was used to examine five (5) constructs: active learning, knowledge construction, social interaction, contextual relevance, and learner autonomy. The five (5) constructs were derived from key principles of Constructivist Learning Theory. These

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constructs provided a guide to the systematic observation and analysis of student's learning behaviours.

Table 2 demonstrated the overall observation frequency by five (5) constructs. The four-point scale was employed as a systematic observation tool for documenting the frequency of recognised behaviours. Thus, rather than taking the place of qualitative analysis, the numerical data enhanced it. This is in line with Maxwell (2010), who revealed that basic numerical count can be used to improve precision in qualitative research without changing the study' design to a qualitative design.

Table 2: Overall Observation Frequency by Construct

Construct	Frequently Observed (4)	Occasionally Observed (3)	Rarely Observed (2)	Not Observed (1)
Active Learning	34	23	5	4
Knowledge Construction	39	17	10	0
Social Interaction	47	15	3	2
Contextual Relevance	34	18	15	0
Learner Autonomy	44	17	4	1

Active learning

From Table 2, the observation results indicate that Active Learning was regularly exhibited in the classroom. Thirty-four (34) observations were scored as Frequently Observed, twenty-three (23) as Occasionally Observed, and while five (5) as Rarely Observed and four (4) as Not Observed. These results indicated that during the majority of the observed sessions, students actively participated in classroom discussions, structural mathematical exercises or activities, and practical learning assignments. This demonstrated an active engagement in learning activities rather than passive absorbing information.

The high frequency of active learning demonstrates that lecturers effectively established a student-centred learning environment (Voutetaki, 2024; Grunenwald et al., 2026) where students actively participated in solving calculation problems rather than passively absorbing knowledge. The Constructivist learning theory, which emphasizes that knowledge is created via active participation and experience, is consistent with this (Piaget, 1972; Vygotsky, 1978). In a similar vein, Freeman et al. (2014) found that by boosting involvement and conceptual understanding, active learning considerably improves students' academic achievement in STEM fields. Additionally, Prince (2004) contended that through debate, problem-solving, and group activities, active learning promotes deeper learning. However, the inconsistent use of simulations suggests that experiential components were not fully maximised, despite evidence showing that experiential and full-scale learning improves conceptual understanding in structural analysis (Grunenwald et al., 2026).

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Knowledge Construction

Knowledge Construction demonstrated strong evidence throughout the observations, with thirty-nine (39) Frequently Observed ratings and seventeen (17) Occasionally Observed ratings. No items (0) were rated as Not Observed, despite the fact that ten (10) observations were categorized as Rarely Observed. Students were able to apply their knowledge during class activities and make connections between new structural principles and what they already knew.

The results indicated that by combining previously learned materials with recently taught structural engineering concepts, students gradually improved conceptual understanding. This is consistent with constructivism, which holds that meaningful learning happens when students actively construct new knowledge from pre-existing cognitive structures (Piaget, 1972: Downey et al., 2022). Additionally, Vygotsky (1978) emphasized that guided interaction within the Zone of Proximal Development improves learning. According to Biggs and Tang (2011), meaningful learning occurs when teaching activities are aligned with targeted learning outcomes, suggesting that the lecturer's use of worked examples and guided explanations may have supported students' conceptual development. Nevertheless, limited opportunities for explanation and reflection indicate that deeper metacognitive processes were not consistently activated. Research shows that knowledge construction is strengthened when learners are required to articulate reasoning and engage in reflective thinking (Chi & Wylie, 2014).

Social Interaction

Of all the constructs, social interaction had the highest amount of observation. Fifteen (15) observations were Occasionally Observed and forty-seven (47) were Frequently Observed whilst there were two (2) Not Observed and three (3) Rarely Observed ratings. During calculating exercises, students regularly worked with classmates, participated in class discussions, and received guidance and advice from the lecturer. In one observed activity, students used the lecturer's structural diagram to support their explanations to their classmates. These behaviours demonstrated cooperative problem-solving, active peer interaction, and the use of structural principle in classroom activities.

The high level of social interaction suggests that students' understanding of structural calculation principles was supported by collaborative learning. Vygotsky (1978) asserts that social interaction is essential to cognitive growth since learning happens through cooperation and communication with more experienced people. Cooperative learning enhances students' performance, motivation, and critical thinking, as Johnson and Johnson (2009) also showed. Students' learning experiences were thus enhanced by the lecturer's support of class debates and peer involvement. Lecturers' facilitation played a key role in sustaining structured interaction. This is consistent with the social constructivist theory, which highlights the importance of interaction in knowledge development (Khalid et al., 2024). However, peer feedback and peer-assisted learning were inconsistently observed, despite evidence that structured peer collaboration enhances conceptual understanding and teamwork skills in engineering and construction education (Rahmawati et al., 2022).

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Contextual Relevance

Also from Table 2, thirty-four (34) observations were rated as Frequently Observed, eighteen (18) as Occasionally Observed, and fifteen (15) as Rarely Observed for Contextual Relevance; whilst no observations (0) were rated as Not Observed. The results indicate that while real-world building examples were frequently used in instructions, there were times when practical applications could have been reinforced.

The findings indicate that the lecturer often associated structural ideas to real-world engineering challenges and construction industry methods, allowing students to understand how theoretical knowledge is applied practically. Because students comprehend how classroom materials relates to professional activities, authentic learning settings boost students' motivation and foster meaningful comprehension (Herrington & Herrington, 2006; Bower, 2017). The comparatively higher amount of "Rarely Observed" evaluations, however, points to opportunities in improving contextual learning by adding more case studies, simulations, or real-world examples.

Learner Autonomy

With ratings of forty-four (44) Frequently Observed, seventeen (17) Occasionally Observed, four (4) Rarely Observed, and one (1) Not Observed, Learner Autonomy also showed a high degree of implementation. While the lecturer provided helpful instructions, students were often seen taking charge of tackling structural calculation difficulties on their own.

The high frequency of learner autonomy suggests that students were motivated to develop into self-sufficient learners who could solve structural problems and make judgments with little guidance. Students demonstrated independence in completing tasks and engaging in guided inquiry, reflecting partial alignment with self-directed learning principles (Reinders, 2022). This result validates the self-directed learning tenets put out by Knowles (1975), who contended that independent learners exhibit higher levels of accountability and drive. Furthermore, according to Deci and Ryan's (2000) Self-Determination Theory, autonomy fosters deeper learner engagement and intrinsic motivation. However, independent information seeking and decision-making confidence were less consistently observed. This indicates that higher-order autonomy skills are still developing, which aligns with findings that learner autonomy requires structured scaffolding and progressive exposure to self-regulated learning tasks (Zimmerman, 2021; Reeve, 2022).

Conclusion and Recommendations

This study demonstrates that innovative, student-centred teaching methods grounded in the Constructivist Learning Theory effectively enhances students' understanding of structural courses. Classroom observations revealed strong evidence of active learning, knowledge construction, social interaction, contextual relevance, and learner autonomy. These factors indicate that students were more engaged and better able to connect theoretical concepts with practical construction applications. Collaborative discussions, problem-based learning, and the use of visual teaching aids encouraged meaningful participation, critical thinking, and conceptual understanding. Although contextual relevance and active learning were consistently observed, opportunities remain to further strengthen authentic learning experiences through

added industry-based case studies, simulations, and structured reflective activities. The findings suggest that lecturers should continue integrating interactive pedagogical approaches into structural education to promote deeper learning and improve students' readiness for professional practice.

However, this study was limited to qualitative classroom observations involving thirteen (13) diploma students within a single institution. Consequently, the findings may not be readily generalisable to other student populations or institutions, as they primarily reflect the observed learning behaviours within the specific classroom context. Future research should employ mixed-methods or quantitative approaches involving larger and more diverse samples, multiple institutions to validate these findings. Additionally, studies should investigate the integration of emerging digital technologies, such as Building Information Modelling (BIM), virtual or mixed reality, and artificial intelligence-assisted learning tools, to further enhance conceptual understanding and learning outcomes in structural education.

Acknowledgements: The authors would like to sincerely thank the Department of Built Environment Studies and Technology, Faculty of Built Environment, Universiti Teknologi MARA Perak Branch, Seri Iskandar Campus, Seri Iskandar, Perak Darul Ridzuan for providing the tools and assistance needed for this study. We would especially want to thank our peers and colleagues for their insightful comments and helpful criticism, which significantly improved the quality of this work.

Funding Statement: No Funding.

Conflict of Interest Statement: The authors declare that there is no conflict of interest regarding the publication of this paper. All authors have contributed to this work and approved the final version of the manuscript for submission to the International Journal of Modern Education (IJMOE).

Ethics Statement: Informed consent was obtained from all participants prior to data collection. All information was anonymised and kept private, and participation was entirely optional.

Author Contribution Statement: Each author made a substantial contribution to the manuscript's development. Wan Nur Syazwani W.M was in charge of the study's conception, designed the research, and overall supervision of the study. Nor Asma Hafidzah H, Wan Nur Hanani W.A and Raja Nurulhaiza R.N was in charge of gathering, analyzing, and interpreting the data. Nurhasyimah A.Z helped with the manuscript's development, critical revision, and literature review. While Mohd Haziman W.I provided critical feedback and helped shape the research. Before the manuscript was submitted, all authors read it and gave their approval.

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EISSN: 2637-0905
Volume: 8 Issue: 31 (September 2026) PP. 2086-2097

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