International Journal of Modern Education
EISSN: 2637-0905
IJMOE
Volume 7 Issue 24 (March 2025) PP. 407-419
DOI: 10.35631/IJMOE.724029

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

GLOBAL ACADEMIC EXCELLENCE

THE IMPACT OF MICRO-LEARNING MODULES TOWARDS LEARNING OUTCOMES: A CASE STUDY OF CHEMICAL ENGINEERING STUDENT

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Article Info:

Article history:
Received date:31.07.2024
Revised date: 13.10.2024
Accepted date: 26.11.2025
Published date: 11.03.2025

To cite this document:

Abu Hashib, S., Md Zaki, N. A., Ibrahim, U. K., Idris, S. A., Veny, H., & Ideres, N. (2025). The Impact Of Micro-Learning Modules Towards Learning Outcomes: A Case Study Of Chemical Engineering Student. *International Journal of Modern Education, 7* (24), 407-419.

DOI: 10.35631/IJMOE.724029

Abstract:

This study explores the effectiveness of micro-learning modules in enhancing student engagement, understanding, and motivation in chemical engineering, specifically in teaching complex concepts related to separation processes. This study successfully collected 100 respondent data through surveys focusing on seven key areas namely pace of learning, engagement, retention of information, clarity of material, preference of learning, motivation, and concept understanding. The findings revealed a strong positive response towards micro-learning. The overall average ratings were high, with engagement rated at 4.13 (SD = 0.73), clarity of material at 4.12 (SD = 0.74), and pace of learning at 4.11 (SD = 0.75), showing a slight lead in engagement. The study concludes that micro-learning is highly effective in enhancing student engagement, understanding, and motivation in chemical engineering education. These findings support the continued integration and development of micro-learning strategies to improve student outcomes, particularly in fields requiring mastery of complex concepts. Further research is suggested to explore enhancements in retention and motivation to maximize the benefits of micro-learning.

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Keywords:

Chemical Engineering Education, Learning Outcomes, Micro-Learning, Student Engagement, Separation Processes

Introduction

Chemical engineering education is essential for providing future engineers with the necessary skills to address complex industrial issues (Th. et al., 2022). Within this discipline, separation processes are remarkable for their complex theoretical foundations and practical applications (Favre, 2020). To name a few, petrochemical, pharmaceutical and environmental engineering sectors rely significantly on separation processes, which include distillation, liquid-liquid extraction, solid liquid extraction (leaching), membrane separation and crystallisation. Mastery of these topics is essential for students to design and optimize processes that are both efficient and sustainable. Engaging students and improving their grasp of difficult subject are frequently challenges faced by traditional teaching approaches, typically heavy focused on notes, textbook and face to face lectures (Hu, 2024; Miller et al., 2013). These conventional approaches may not adequately prepare students for real-world problem-solving or foster deep comprehension of the material (Ammar et al., 2024; Kamran et al., 2023; Wrenn & Wrenn, 2009)

As the engineering field evolves, there is an increasing need for that cater to the diverse learning styles of students and leverage modern technological advancements to enhance learning outcomes (Dixit et al., 2024) . Micro-learning method has emerged as a promising educational strategy that has proven particularly suitable to effectively address these needs(Calixtro, 2023; De Rosa et al., 2024; McNeill & Fitch, 2023; Mohammed & Wakil, Karzan, Nowroly, 2018). This method comprises breaking down of material into clear and focussed segments that are more easily received and remembered by students. Micro-learning modules frequently combine multimedia components, including interactive simulations, infographics, and videos, to enhance accessibility and engagement of the learning process (Garshasbi et al., 2021). These modules provide flexibility, allowing students to learn at their own pace and revisit complex topics as needed, thus reinforcing their understanding (Calixtro, 2023; Mohammed & Wakil, Karzan, Nowroly, 2018). Microlearning allows work-based learners to acquire new knowledge or skills in a timely manner to meet their immediate requirements in a rapidly evolving world (Leong et al., 2021). Additionally, microlearning can assist work-based learners in completing a specific, actionable task. Microlearning is particularly advantageous in a professional setting due to these advantages (Leong et al., 2021).

The issue with the present learning system is that students frequently get stucked while using conventional methods since educators are unable to inspire them to learn quickly and develop creative thinking (De Vries et al., 2019; Garshasbi et al., 2021; Leong et al., 2021; McNeill & Fitch, 2023). Prior research has emphasised the effectiveness of micro-learning in other educational environments, such as business and healthcare (Mohammed & Wakil, Karzan, Nowroly, 2018). However, the impact of micro-learning modules on student engagement and understanding in chemical engineering separation processes, compared to standard teaching methods, has not been extensively studied. The purpose of this study is to evaluate the impact of micro-learning modules on the understanding and involvement of chemical engineering students. By addressing these objectives, it is expected that the study will be able to offer

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insightful information about the possible benefits and best practices for incorporating micro-learning into chemical engineering curriculum, which could help in the development of more effective and interesting instructional frameworks.

Literature Review

Micro-learning has been gaining traction in various educational fields, including engineering education (Calixtro, 2023; Leong et al., 2021). Previous studies have shown that micro-learning can significantly enhance student engagement and understanding (Kossen & Ooi, 2021; McNeill & Fitch, 2023). Furthermore, micro-learning modules improved students' learning abilities and retention rates by breaking down complex topics into manageable, bite-sized units. This approach aligns well with the cognitive load theory, which suggests that learning is more effective when information is presented in smaller, more digestible segments (Balasundaram et al., 2024; Salleh et al., 2022). It refers to the student's mental effort and dedication to understanding the subject matter.

In the context of microlearning, the outcome is that students can easily dedicate their mental energy to short, focused tasks without feeling overwhelmed or drained. Microlearning encompasses a variety of activities designed to deliver short, focused bursts of content to enhance learning efficiency and retention. Table 1 presents typical applications of microlearning activities, detailing their descriptions and benefits. It highlights formats such as short videos, Youtube series, Massive Open Online Courses (MOOCs), text, images, and audio clips. Each type of microlearning activity is designed to enhance understanding and retention through different sensory inputs and interactive elements. The flexibility and accessibility of microlearning are emphasised in all activities, allowing learners to engage with content effectively and efficiently and to suit a wide range of learning preferences.

In engineering education, micro-learning has been particularly effective in complex and technical courses (Balasundaram et al., 2024; Rof et al., 2024). The modular nature of micro-learning allows students to focus on specific topics at their own pace, which is crucial in technical subjects where students may need additional time to grasp complex concepts. Micro-learning has been shown to significantly enhance student engagement and understanding in various educational contexts (Mohammed & Wakil, Karzan, Nowroly, 2018). Multiple studies on micro-learning by applications in engineering and other disciplines found consistent student performance and satisfaction improvements. Multiple studies on micro-learning applications in engineering and other disciplines have found consistent improvements in student performance and satisfaction. For example, a study conducted by Parno et al. (2021) utilized the IBL-STEM model with formative assessment to improve students' understanding of fluid dynamics (Parno et al., 2021). The study involved 34 high school students and demonstrated a significant increase in students' conceptual understanding. Despite these improvements, students still faced challenges with certain fluid dynamics concepts, such as flow rate and aerodynamic lift. This highlights how structured, focused approaches, like micro-learning or IBL-STEM, can significantly enhance student outcomes in complex subjects.

A study conducted at Universiti Utara Malaysia revealed positive responses from accounting students toward microlearning (Salleh et al., 2022). The students appreciated the flexibility of microlearning, as it allowed them to review material at their own pace, reducing the burden of attending long lectures on computers or mobile devices. This approach facilitated better understanding and provided more opportunities for students to discuss challenges with

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educators and peers. Pre-recorded videos enabled students to prepare before class, enhancing their critical thinking during problem-solving sessions. However, the study also highlighted challenges, such as the time-consuming nature of video creation and the need for educators to develop video-making skills before the semester begins. The authors concluded that microlearning positively impacts students' motivation and behaviour, making it easier for educators to guide students toward achieving learning outcomes.

Table 1: Typical Applications Of Microlearning Activities

Type of Microlearning Activity	Description	Benefits
Videos sharing	Short videos, less than 10 minutes long, that cover specific topics or concepts.	Visual and auditory elements enhance understanding and retention. Effective for explaining complex concepts quickly.
YouTube Videos series	Educational videos uploaded by lecturers to platforms like YouTube, covering course material and additional content.	Accessible anytime, allows for revisiting complex topics, and often includes visual aids to enhance understanding.
MOOCs (Massive Open Online Courses)	Online courses available to a large number of participants, often free, covering a wide range of subjects.	Provides structured learning from leading universities and institutions, includes various multimedia resources, and offers certificates upon completion.
Text (phrases, short paragraphs)	Brief written content focused on specific topics or concepts.	Allows for quick consumption and easy understanding of key points.
Images (photos, illustrations)	Visual content used to explain or highlight key points.	Enhances understanding and retention through visual representation.
Audio (short snippets of speech or music)	Short audio clips used to convey information or reinforce learning.	Offers auditory learning and can be easily integrated into other learning activities.

In another study, Neo and Ludin at the Multimedia University Malaysia explore the impact of emerging technologies, such as mobile devices and web-based platforms, on education (Ludin et al., 2018). Their work addresses the challenge of maintaining student attention and engagement during lengthy lessons. It discusses the development of a microlearning application within a multimedia environment, structured around Gagne's Nine Events of Instruction, to improve learning comprehension for undergraduate students. Student feedback showed a positive response to the microlearning approach, highlighting increased motivation and understanding. The findings support the integration of microlearning applications through web and mobile devices in technology-enhanced classrooms in higher education.

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Methodology

A systematic approach was used to gather student feedback surveys with questionnaires measuring student happiness and engagement. The gathered data were examined to evaluate the efficacy of the micro-learning modules in comparison to more conventional teaching methods. This analysis assisted in determining the strengths and areas for improvement of the micro-learning modules.

Participants

This study utilized action research, with data collected through survey which utilized a Likert scale as the primary measurement tool. The research focused on 100 voluntary students which enrolled in the Separation Processes course, a core subject for Bachelor of Chemical Engineering students.

Instruments

The survey concentrated on seven critical areas: motivation, concept of understanding, preference of learning format, clarity of material, retention of information, engagement, and pace of learning. The overall efficacy of microlearning as a pedagogical approach is significantly influenced by each of these areas. The responses are rated based on a Likert scale, where participants indicate their level of agreement with a statement or question. Each category corresponds to a numerical value, ranging from 5 to 1, with 5 representing Strongly Agree (indicating the highest level of agreement or satisfaction) and 1 representing Strongly Disagree (indicating the lowest level of agreement or dissatisfaction). Intermediate responses such as Agree (4), Neutral (3), and Disagree (2) allow participants to express varying degrees of agreement or disagreement. This scale provides a structured way to quantify subjective opinions, making it easier to analyze and interpret the data for patterns in participant responses as Fig 1.

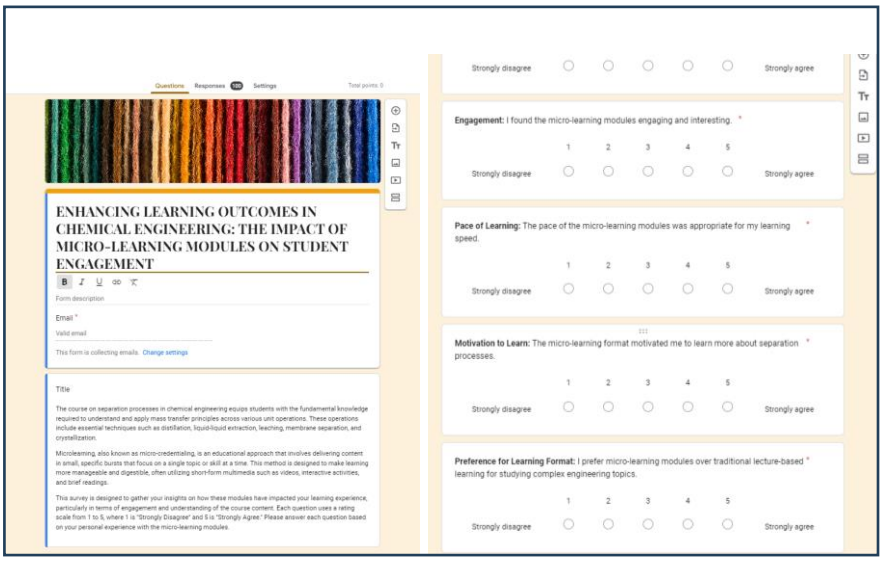

Figure 1 Likert Scale Survey on Micro-Learning Modules in Chemical Engineering Separation Processes Course.

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Learning Content And Platform

Micro-learning lessons were carefully constructed to cover chemical engineering separation processes. Each section was short and appealing using a pre-recorded video broadcast on Learning Management Systems (LMS) consisting of YouTube or the internal platform site U-Future, as illustrated in Fig 2. This multimedia method offered a more dynamic experience to accommodate different learning styles and help students visualize complex processes. The modules covered Concepts of Liquid-Liquid Extraction and Application, Single–Stage Equilibrium Extraction, Multi-Stage Countercurrent Extraction, Ternary Phase Diagram, Partially Miscible Liquid, Fully Immiscible Liquid, and Extraction Equipment. The micro-learning modules were deployed in a separation processes course, ensuring seamless integration into the existing curriculum. The LMS platform facilitated easy access and consistent engagement, allowing students to progress through the modules at their own pace while maintaining a structured learning environment.

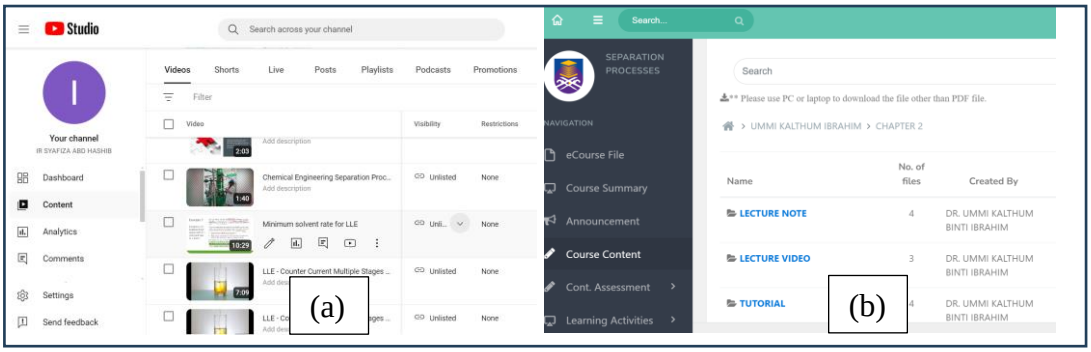

Figure 2 Pre-recorded Video in LMS (a) Youtube and (b) Ufuture

Results and Discussion

The survey, which was responded by 100 students, was designed to assess the influence of microlearning on a variety of aspects of their educational experience. The survey concentrated on seven critical areas: motivation, concept of understanding, preference of learning format, clarity of material, retention of information, engagement, and pace of learning. The overall efficacy of microlearning as a pedagogical approach is significantly influenced by each of these areas. The subsequent sections provide an analysis of the survey results, emphasising the students' perspectives and experiences in each of these domains. The analysis of these results will enable us to gain a more comprehensive understanding of the advantages and obstacles associated with microlearning, as well as to develop strategies for optimising its implementation in educational environments. The responses are distributed across five categories: Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree.

Figure 3 showed responses on engagement. A significant portion of students (34%) strongly agreed that the microlearning modules were engaging and interesting. This suggests that over a third of the participants found the modules highly effective in capturing their interest and keeping them engaged. The largest group of students (47%) agreed with the statement. Combining this with the strongly agree category, it indicates that 81% of the students had a positive perception of the engagement level of the microlearning modules.

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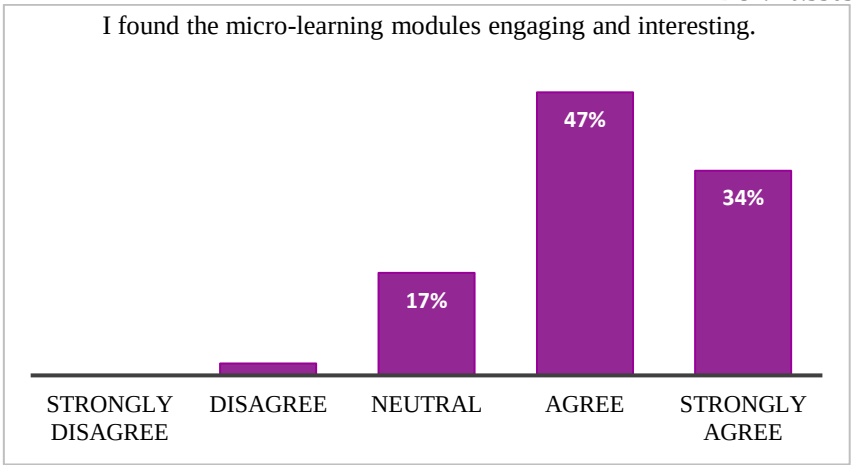

Figure 3: Responses On Engagement

This majority suggests that the microlearning approach successfully appeals to most students. 17% of the students expressed no opinion, neither agreeing nor disagreeing with the statement. This suggests that although the modules were moderately engaging, they did not stand out as highly engaging for this group. However, the absence of responses in the Disagree and Strongly Disagree categories is a positive indicator. Similarly, a study by Gherman, Turcu, and Turcu (2023) reported that the implementation of microlearning units in a computer graphics course provided students with a convenient and tailored learning experience. While it was essential for students to actively participate to develop key skills, the personalized advice and structured learning paths enhanced the learning experience, further supporting the moderate engagement levels observed in their study (Gherman et al., 2021).

The graph in Figure 4 depicts student responses regarding their motivation to learn more about separation processes through the micro-learning format. The results indicate that 45% of students agreed and 31% strongly agreed that the micro-learning format motivated them to learn more about the subject. This totals to 76% of students showing a positive response toward the motivational aspect of micro-learning (Garshasbi et al., 2021; Mohammed & Wakil, Karzan, Nowroly, 2018). Meanwhile, 20% of students remained neutral, and only a small percentage (4%) disagreed, with no students strongly disagreeing.

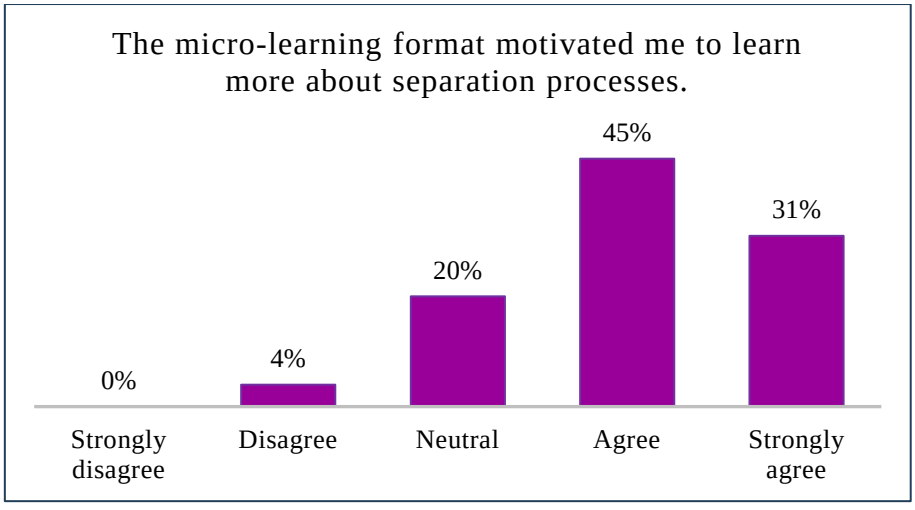

Figure 4: Response On Motivation To Learn

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When comparing these results to the engagement survey, we see a similarly positive trend. In the engagement survey, 34% of students strongly agreed and 43% agreed that the micro-learning modules were engaging and interesting, totalling 77% positive responses. Here, the neutrality percentage was 23%, and no students disagreed or strongly disagreed.

The similarities in the distribution of responses across both surveys highlight a consistent positive perception of micro-learning among students. The slight variation, with motivation receiving slightly more agreement and less neutrality, suggests that while students generally find micro-learning engaging, it may have an even stronger impact on their motivation to delve deeper into specific topics (Rof et al., 2024). This consistency underscores the effectiveness of micro-learning in not only capturing student interest but also encouraging a deeper commitment to learning (Fitria, 2022). These findings support the continued use and development of micro-learning strategies in educational settings to enhance both engagement and motivation among students (Nikou & Economides, 2018).

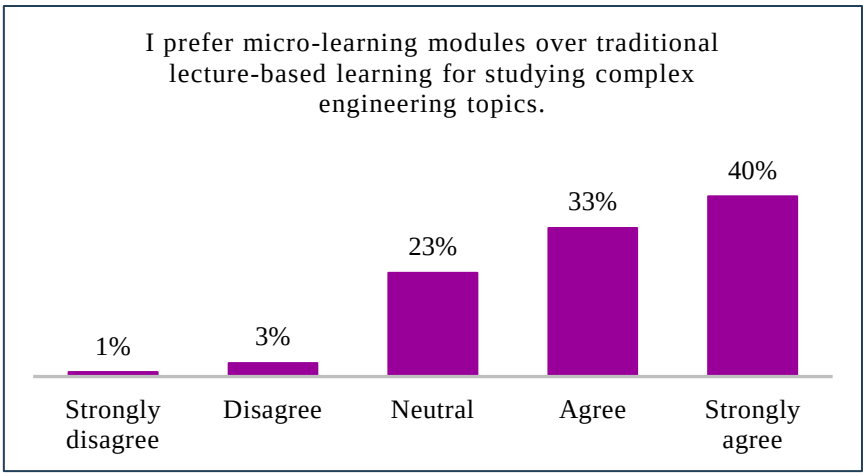

Figure 5: Response on Preference for Learning Format

According to Figure 5, most students prefer micro-learning to traditional techniques. In particular, 40% of students strongly agreed and 33% agreed. This suggests 73% of students prefer micro-learning. The high percentage suggests that most students find micro-learning more useful and entertaining than lengthier lectures (Leong et al., 2021; Tira Nur Fitria, 2022). Fewer students dissatisfied with micro-learning: 4% disagreed or strongly disagreed. This low percentage suggests few pupils prefer traditional methods. The little negative feedback supports micro-learning as a preferred teaching method, especially in engineering, where complex concepts are essential (Rof et al., 2024).

The graph in Figure 6 shows the responses regarding the effectiveness of micro-learning modules in improving students' understanding of key concepts in separation processes. According to the data, 48% of students agreed, and 31% strongly agreed that the micro-learning modules helped improve their understanding, totaling 79% positive responses. Meanwhile, 20% of students remained neutral, and only 1% disagreed, with no students strongly disagreeing.

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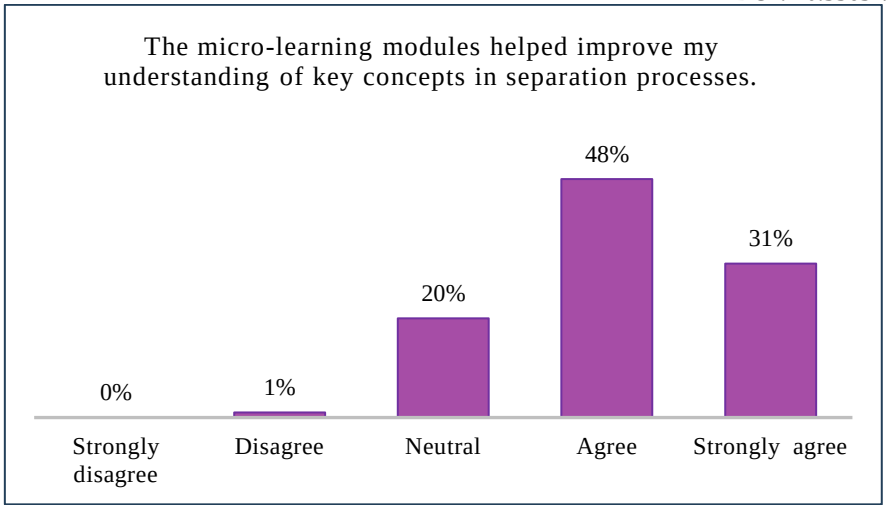

Figure 6: Response on Understanding of Concepts

In contrast to the learning format preference data, which indicated that 40% of students firmly agreed and 33% agreed that they preferred micro-learning over traditional lecture-based learning, there is a clear relationship, Both datasets show that micro-learning is preferred and effective (Lin et al., 2023). The high positive answers in grasping ideas and learning format choice imply that students not only appreciate micro-learning but also find it helpful in understanding hard subjects (McNeill & Fitch, 2023; Rof et al., 2024, Study.com, n.d). This alignment highlights the value of micro-learning in providing a more effective educational approach, particularly for intricate topics like separation processes in engineering. The preference for micro-learning, coupled with its impact on understanding, underscores its potential as a significant tool in modern education.

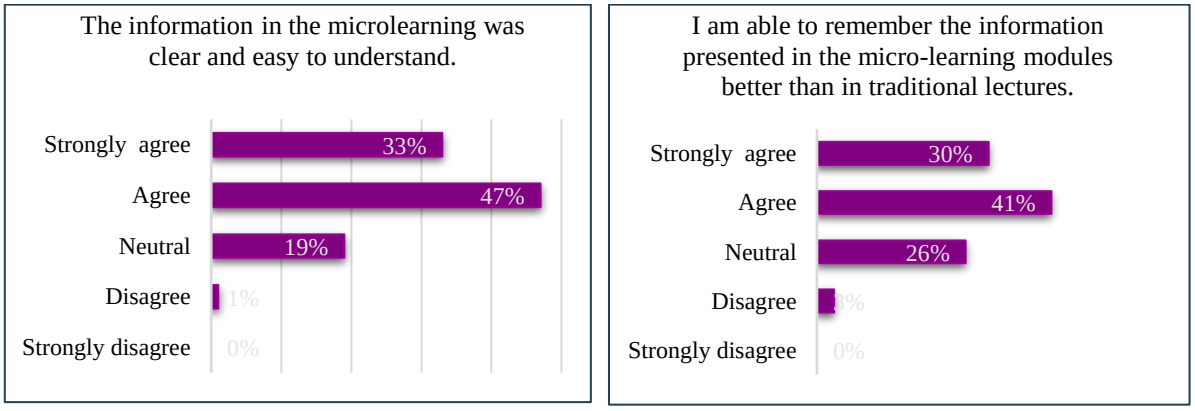

Figure 7: Responses on Clarity of Material and Retention of Information

Figure 7 presents the survey results on how micro-learning modules have impacted students' understanding of key concepts in separation processes. The data indicates a strong positive response, with 48% of students agreeing and 31% strongly agreeing that these modules have improved their understanding. This means that 79% of the students found the micro-learning approach beneficial for grasping complex concepts. There were 20% of students who remained neutral suggest that while they did not find the modules significantly beneficial, they did not find them ineffective either. However, 1% of students expressed disagreement, suggesting a negligible level of discontent with the micro-learning approach. These results are consistent

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with the preference for micro-learning over traditional lecture-based learning, as shown in previous figures 3-6. The high levels of agreement in both understanding and preference suggest that micro-learning not only engages students but also enhances their comprehension of complex material (Fidan, 2023). This reinforces the notion that breaking down information into smaller, manageable segments can significantly aid in the learning process, making it a valuable strategy in engineering education.

Figure 8 illustrates the students' responses regarding the appropriateness of the pace of the micro-learning modules for their learning speed. A significant 77% of students responded positively, with 34% strongly agreeing and 43% agreeing that the pace was appropriate, while 23% remained neutral. Notably, there were no negative responses (disagree or strongly disagree), indicating overall satisfaction with the pacing. These results align with previous figures, such as Figure 4, where 76% of students found the micro-learning format motivating, and Figure 6, where 79% reported improved understanding of key concepts. The consistently high positive feedback across aspects like motivation, understanding, engagement, and pacing suggests that micro-learning effectively caters to diverse learning needs and speeds, contributing to a positive overall learning experience (Balasundaram et al., 2024; Fidan, 2023).

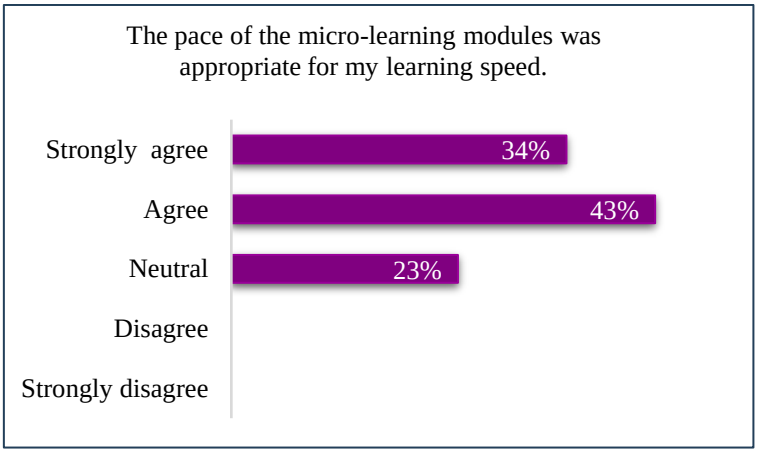

Figure 8: Responses on Pace of Learning

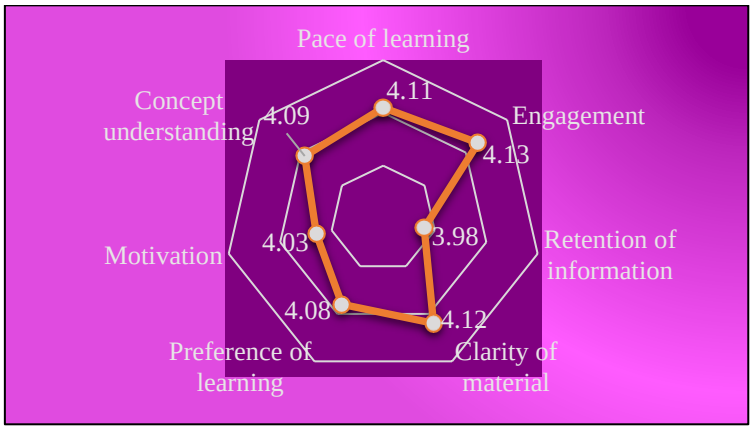

Figure 9: Average overall ratings

The radar chart in Figure 9 presents the overall average ratings for various aspects of the micro-learning modules: pace of learning, engagement, retention of information, clarity of material, preference of learning, motivation, and concept understanding. All categories received high

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average ratings, with engagement (4.13), clarity of material (4.12), and pace of learning (4.11) leading slightly. Preference of learning (4.08) and concept understanding (4.09) also received strong ratings, while retention of information (3.98) and motivation (4.03) were slightly lower but still positive. These results demonstrate that students generally found the micro-learning modules effective across all evaluated aspects. The high ratings in engagement and clarity suggest that students found the material well-presented and easy to follow. The slightly lower but still strong ratings for retention and motivation indicate areas where further enhancements could make micro-learning even more effective.

Conclusion

Overall, the data reinforces the positive impact of micro-learning on student learning experiences. The consistently high ratings across various dimensions highlight the effectiveness of micro-learning in delivering educational content that is engaging, clear, and appropriately paced. These insights suggest that micro-learning can significantly enhance the learning process, making it a valuable tool in modern education, particularly in fields requiring the mastery of complex concepts. The findings support the continued integration and development of micro-learning strategies to further improve student outcomes. The importance of education in the 21st century lies in its ability to develop individuals, stimulate innovation and advancement, cultivate worldwide knowledge, and promote personal and societal growth.

Acknowledgement

The authors gratefully acknowledge the Kurita Water & Research Foundation for providing the financial support under the KWEF Research Grant Programme (Grant No: 100-TNCPI/INT 16/6/2 046/2023). The authors also would like to acknowledge the students of CHE544, School of Chemical Engineering, UiTM Shah Alam (March-August 2024), for the responses.

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International Journal of Modern Education
EISSN: 2637-0905
IJMOE
Volume 7 Issue 24 (March 2025) PP. 407-419
DOI: 10.35631/IJMOE.724029

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