

Enhancing TVET Students' Learning Experience through Digital Learning Module Development: A Case Study in Higher Education

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DOI: <https://doi.org/10.47772/IJRISS.2026.100400361>

Received: 15 April 2026; Accepted: 20 April 2026; Published: 09 May 2026

ABSTRACT

This study examines the development and evaluation of a digital Learning Module named the CAD/CAM learning module for industrial machining technology, aimed at enhancing engagement and competence among Technical and Vocational Education and Training (TVET) students. The module was developed using the ADDIE instructional design model as a framework and guided by experiential learning principles, incorporating multimedia features, structured video tutorials, and targeted Mastercam exercises. Thirty (30) undergraduate machining technology students from Malaysian Technical University Network (MTUN) institutions participated. A quantitative approach was applied using a structured questionnaire to assess students' perceptions, learning interest, and the relationship between these variables. Data were analysed using descriptive statistics and Pearson correlation analysis. Findings revealed highly positive perceptions of the module's design and a strong, statistically significant relationship between perceptions and learning interest ($r = 0.736, p < 0.001$). The results highlight the value of integrating systematic instructional design with experiential learning principles to create effective digital modules in TVET, with potential application across other technical disciplines.

Keywords: Technical and Vocational Education and Training (TVET), digital learning module, machining module, instructional design, higher education

INTRODUCTION

Technical and Vocational Education and Training (TVET) plays a pivotal role in equipping learners with industry-relevant skills, directly contributing to workforce readiness and national economic growth (UNESCO-UNEVOC, 2020). Within this context, Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) has become an essential component in modern machining, engineering, and manufacturing, enabling graduates to meet the technological demands of modern industries increasingly driven by digital fabrication and precision manufacturing (Kumar & Chandrasekaran, 2019; Muller, 2021).

The rapid advancement of technology has also driven the adoption of digital learning modules, which provide flexibility, interactivity, and a more engaging learning experience compared to conventional teaching methods (Kebritchi, Lipschuetz, & Santiago, 2017). When designed effectively, digital modules can transform traditional instruction into dynamic, student-centred learning environments that promote deeper understanding and sustained engagement (Moore et al., 2018). In TVET, where practical skills must be closely integrated with theoretical knowledge, digital modules can serve as a bridge between theory and practice, offering simulated environments and interactive exercises to strengthen learning outcomes (Zhang & Han, 2022; Mazlan et al., 2025).

However, the effectiveness of such modules depends greatly on their instructional design. Poorly structured content, weak curriculum alignment, and limited interactivity can diminish student engagement and reduce the value of the learning experience (Al-Azawei, Parslow, & Lundqvist, 2017). In Malaysian TVET institutions, CAD/CAM instruction still tends to rely heavily on static materials and instructor-led demonstrations, which may not fully sustain students' interest or encourage independent learning (Lim, Lee, & Yap, 2020; Hussin et al., 2021). As a result, many students particularly in mastering Mastercam software, find the subject challenging, which can limit their willingness to explore its applications beyond the classroom (Rahman, Abdullah, & Osman, 2022). This lack of sustained interest can negatively impact skill mastery and the ability to apply competencies in real-world settings (Ryan & Deci, 2020; Norazmi et al., 2021).

To address this challenge, this study develops and evaluates a purpose-built digital CAD/CAM learning module for industrial machining technology using an integrated methodological approach. The ADDIE instructional design model was used to structure the module's development, ensuring systematic needs analysis, targeted design, and iterative evaluation. Simultaneously, Kolb's Experiential Learning Cycle was embedded into the learning activities to promote active engagement, reflective practice, and application of knowledge in authentic machining contexts. This dual-framework approach ensures that the module is not only pedagogically sound but also aligned with the experiential and skill-based nature of TVET. The study examines TVET students' perceptions of the module's format and content, their learning interest when using it, and the relationship between these two variables.

Research Questions

1. What is the level of students' perceptions regarding the content of the developed digital CAD/CAM module?
2. What is the level of students' learning interest when using the module?
3. Is there a statistically significant relationship between students' perceptions of the module's content and their learning interest?

Research Hypothesis

Ho: There is no statistically significant relationship between students' perceptions of the developed digital CAD/CAM module's content and their learning interest.

Ha: There is a statistically significant relationship between students' perceptions of the developed digital CAD/CAM module's content and their learning interest.

Aligning experiential learning in cultivating TVET learning experiences

Previous studies have shown that embedding Kolb's experiential cycle in technical and vocational education enhances conceptual understanding, confidence, and learner motivation. For example, Pamungkas et al. (2019) demonstrated that experiential learning fosters stronger cognitive, psychomotor, and affective outcomes by allowing students to "see, do, reflect, and apply" their knowledge in authentic technical tasks. Similarly, Winandari et al. (2022) reported that vocational students valued experiential e-modules with video demonstrations, with over 90% using them as primary learning resources because they supported visual understanding and practical engagement. These findings provide strong justification for integrating Kolb's theory into the module development, as it aligns with TVET students' learning preferences and ensures a balance between structured instructional design (ADDIE) and experiential, skill-based learning.

Research Conceptual Framework

This conceptual framework illustrates how digital multimedia elements within the CAD/CAM learning module reinforce each stage of Kolb's Experiential Learning Cycle. The Concrete Experience stage is supported through realistic video demonstrations, CAD/CAM simulations, and multimedia-based machining tasks that provide

authentic exposure to industry-relevant processes. The Reflective Observation stage is enhanced through the replay, pause, and comparison features of video tutorials, allowing students to evaluate their performance and analyse differences between their output and expert demonstrations. Abstract Conceptualisation is facilitated by visual explanations, diagrams, and annotated instructional content that connect experiential tasks to theoretical machining concepts. Finally, Active Experimentation is promoted through open-ended digital exercises that require learners to apply theoretical knowledge, adjust machining parameters, and design new toolpaths independently. Together, these elements create a comprehensive digital experiential learning environment that enhances engagement, understanding, and technical competence among TVET students. Figure 1 below illustrates how video demonstrations, simulations, reflective features, conceptual visuals, and application-based tasks support each stage of experiential learning.

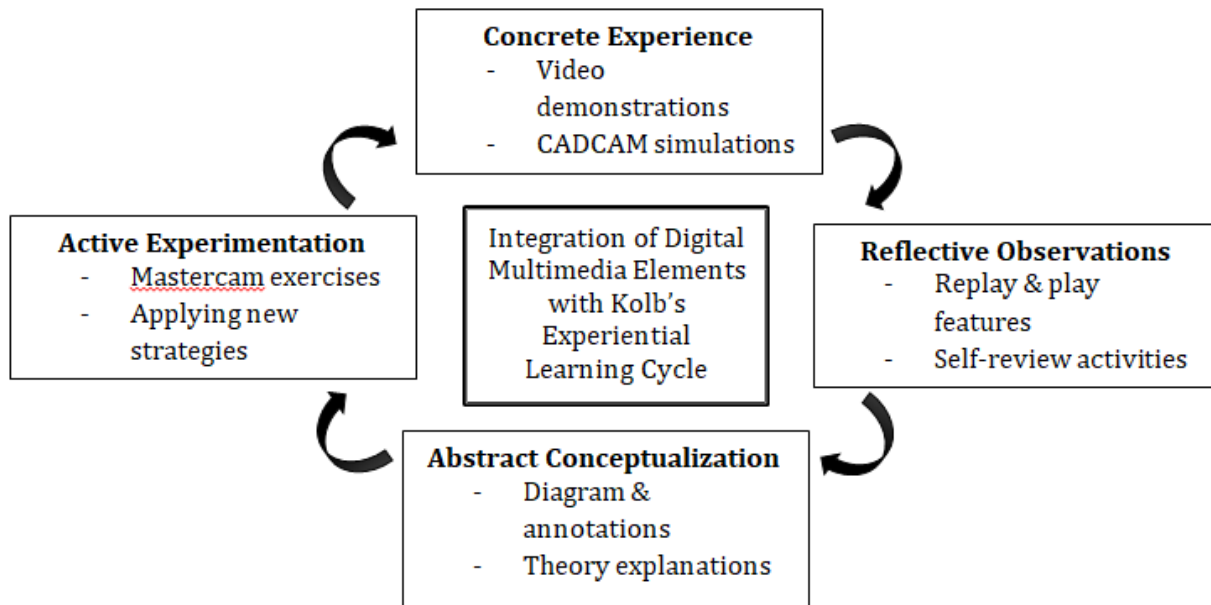


Figure 1: Integration of digital multimedia elements within the CAD/CAM module aligned to Kolb's Experiential Learning Cycle.

Meanwhile, the ADDIE instructional design model provided the structural backbone of the module development process. During the Analysis phase, students' learning needs and gaps in using Mastercam software were identified. The Design phase focused on defining learning objectives, selecting appropriate multimedia strategies, and planning task-oriented instructional content. The Development phase produced structured video tutorials, CAD/CAM-based exercises, and interactive simulations. The Implementation phase involved delivering the module to selected students from the Malaysian Technical University Network (MTUN). Finally, the Evaluation phase assessed students' perceptions, engagement, and overall learning experience.

METHODOLOGY

This study employed a quantitative research approach using a structured survey to collect data from undergraduate students in machining-related TVET programmes. The main aim was to evaluate students' perceptions of the content of a newly developed digital CAD/CAM learning module, examine their level of learning interest, and analyse the relationship between these two variables. The survey was distributed online via Google Forms, allowing students to complete it flexibly. While the responses were analysed using the Statistical Package for the Social Sciences (SPSS) to generate descriptive summaries and inferential analyses.

Sample & Population

This study adopted a cross-sectional survey design, which is widely recognised as effective for capturing responses from a target group at a single point in time and for exploring relationships between variables in educational research (Creswell & Creswell, 2018). The focus was on TVET students in the machining field from selected Malaysian Technical University Network (MTUN) institutions.

The target population consisted of Year 3 and Year 4 students with prior experience using Mastercam software, ensuring that participants were able to provide informed and meaningful feedback on the developed module. A purposive sampling technique was applied to select participants who met these criteria, and a total of 30 students voluntarily took part in the study. Informed consent was obtained prior to data collection, and both confidentiality and anonymity were safeguarded throughout the process in line with the ethical guidelines established by the British Educational Research Association (BERA, 2018). Although the study involved 30 participants, this sample size is defensible for a preliminary exploratory quantitative design. Cohen (1988) indicates that, for a two-tailed Pearson correlation test at $\alpha = .05$, a sample size of approximately 28 is sufficient to detect a large effect size ($r = .50$) with a statistical power of .80. Furthermore, Johanson and Brooks (2010) recommend that at least 30 participants are adequate for pilot or initial scale development studies. In addition, for questionnaire-based research, Bujang et al. (2018) suggest that a minimum of 30 respondents is generally sufficient for reliability analysis. Nevertheless, the findings should be interpreted as preliminary and require further validation using larger and more diverse samples.

Research Instrument

The research instrument was a structured questionnaire consisting of three sections, adapted and modified from relevant past studies to suit the objectives and context of this research.

- Section A: Demographic Information — Gathered background details including gender and year of study.
- Section B: Students' Perceptions of the Module's Format and Content — Contained five items assessing the attractiveness and usefulness of the module's multimedia features, the clarity of tutorial videos, and the appropriateness of the exercises provided for Mastercam learning. These items were adapted from previous studies on multimedia-based learning modules and instructional design evaluation (e.g., Al-Azawei, Parslow, & Lundqvist, 2017; Moore, Dickson-Deane, & Galyen, 2018).
- Section C: Students' Learning Interest — Comprised seven items measuring enjoyment, confidence, and the ability to learn independently when using the module. The items were developed in alignment with the self-determination theory framework, which emphasises the importance of intrinsic and extrinsic motivation in sustaining engagement (Ryan & Deci, 2020).

All items in Sections B and C were measured using a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The instrument was reviewed by three subject-matter experts in TVET education, instructional design, and CAD/CAM applications to ensure *content validity*, defined as the extent to which an instrument adequately covers the construct it intends to measure (Polit & Beck, 2006). Expert feedback was used to refine the wording and sequence of several items to improve clarity, relevance, and alignment with research objectives.

The adaptation and modification process followed recommendations from DeVellis (2017) on scale development, ensuring that while items were grounded in prior validated instruments, they were contextually tailored for TVET students in the machining field. This approach maintained theoretical consistency while enhancing applicability to the specific learning environment of CAD/CAM instruction.

Data Analysis

Data collected from the questionnaire were analysed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics, specifically the mean (M) and standard deviation (SD), were used to summarise students' responses for each item in Sections B and C. The interpretation of mean scores followed the categorisation proposed by Miller (2008), which classifies response levels into five categories, ranging from Very Low to Very High. This classification provides a clear benchmark for interpreting the extent of students' perceptions and learning interest.

Table 1 Interpretation of Mean Scores

Mean Score Range	Interpretation
4.21 – 5.00	Very High
3.41 – 4.20	High
2.61 – 3.40	Moderate
1.81 – 2.60	Low
1.00 – 1.80	Very Low

In addition to descriptive analysis, a Pearson product-moment correlation analysis was conducted to examine the relationship between students’ perceptions of the module and their learning interest. Interpretation of the correlation coefficient (*r*) was based on Cohen (1988), where values between 0.10–0.29 are considered small, 0.30–0.49 moderate, 0.50–0.69 large, and 0.70–0.89 very strong. The significance level (*p*) was set at 0.05, indicating that results with $p < 0.05$ were considered statistically significant, while $p < 0.01$ indicated a highly significant result.

RESULTS AND DISCUSSION

This section presents the findings in relation to the study objectives, focusing on students’ perceptions of the digital CAD/CAM module and their learning interest when using it. The analysis employs descriptive statistics and correlation analysis to interpret the effectiveness of the module within a TVET context. A total of 30 students from machining-related programmes participated in this study. All respondents had prior exposure to Mastercam software, ensuring that their evaluations were grounded in relevant learning experience. The demographic distribution, predominantly male, reflects the existing gender pattern in machining-based TVET programmes, as reported in previous Malaysian studies.

Table 2 Analysis of demographic

Variable	Category	N	%
Gender	Male	25	83.3
	Female	5	16.7
Year of Study	Year 3	21	70.0
	Year 4	9	30.0

The demographic data reveals that most respondents were male (83.3%). This reflects the gendered nature of technical programmes and the dominance of male participation in machining-based fields, as also observed in prior Malaysian TVET studies (Norazmi et al., 2021; Hussin et al., 2021).

Students’ Perceptions on the Content of the Digital CAD/CAM Module

Table 3 presents students’ responses regarding the structure, multimedia design, and clarity of the module content. All five items received ratings in the “High” or “Very High” categories, indicating strong overall satisfaction with the module’s format and content.

Table 3 Analysis of students’ perceptions on the format and content of the digital CAD/CAM module

Item	Mean	SD	Interpretation
The multimedia elements used in the module encouraged me to use Mastercam more frequently	4.50	0.63	Very High
The tutorial video content helped me understand Mastercam applications	4.57	0.50	Very High
The multimedia provided helped me visually understand the topics covered	4.60	0.50	Very High
The use of tutorial videos in the module made my learning process and enhances instructional accessibility	4.40	0.56	Very High
The Mastercam exercises in the module matched my level of understanding	4.23	0.73	High

The highest mean score was observed for the item “The multimedia provided helped me visually understand the topics covered” (M = 4.60, SD = 0.50), highlighting the importance of visual elements in facilitating comprehension of CAD/CAM concepts. These findings indicate that multimedia integration not only enhances learning interest but also facilitates cognitive processing by linking abstract machining concepts with visual and procedural representations. This is particularly important in technical domains that require spatial understanding and sequential operations.

Similarly, strong ratings for tutorial video-related items (M = 4.57, SD = 0.50; M = 4.40, SD = 0.56) demonstrate that structured instructional delivery supports effective learning experiences. Step-by-step demonstrations enable students to revisit procedures, reinforce understanding, and bridge the gap between theory and practice. This finding is consistent with prior research indicating that multimedia-based instructional materials enhance conceptual understanding and learner engagement in digital environments (Moore et al., 2018; Zhang & Han, 2022; Al-Azawei et al., 2017).

The slightly lower mean score for the alignment of exercises with students’ ability levels (M = 4.23, SD = 0.73), although still categorised as “High,” suggests an area for further improvement. This indicates that while the module effectively supports learning, the level of task difficulty may not fully accommodate variations in student competency. From an instructional design perspective, this highlights the need for adaptive or scaffolded learning tasks to ensure that learners remain appropriately challenged without experiencing cognitive overload. This observation aligns with Kebritchi et al. (2017), who emphasise the importance of aligning instructional activities with learners’ abilities in digital learning environments.

Overall, the findings demonstrate that the effectiveness of the module is strongly influenced by multimedia integration, instructional clarity, and appropriate task design.

Students’ Learning Interest When Using Digital CAD/CAM Module

Table 4 shows consistently high levels of learning interest, with mean scores ranging from 4.23 to 4.60, indicating that the module effectively enhanced students’ engagement, confidence, and motivation.

Table 4 Analysis of students’ learning interest through the digital CAD/CAM module

Item	Mean	SD	Interpretation
I enjoyed learning Mastercam using this module	4.53	0.51	Very High
This module made me feel more competent in using Mastercam	4.43	0.63	Very High

This module increased my interest in using Mastercam	4.60	0.50	Very High
I can learn Mastercam using this module without help from peers or lecturers	4.23	0.73	High
This module increased my confidence in using Mastercam	4.30	0.60	High
This module motivated me to actively engage in learning this topic	4.40	0.56	Very High
This module helped resolve my difficulties in understanding how to use Mastercam	4.40	0.56	Very High

The highest-rated item, “This module increased my interest in using Mastercam” (M = 4.60, SD = 0.50), suggests that the module successfully fosters positive affective responses toward a technically demanding subject. This implies that well-designed digital learning environments can make complex technical content more engaging and accessible to learners.

High mean scores for enjoyment (M = 4.53, SD = 0.51) and perceived competence (M = 4.43, SD = 0.63) further indicate that the module supports students’ confidence in applying technical skills. This finding suggests that structured digital instruction, combined with guided practice, can strengthen learners’ self-efficacy, which is essential for sustaining learning interest in technical education.

In addition, relatively high ratings for independent learning (M = 4.23, SD = 0.73) and confidence (M = 4.30, SD = 0.60) indicate that the module promotes learner autonomy. Students were able to engage with the content independently, suggesting that the instructional design provides sufficient clarity and guidance. This is particularly relevant in TVET contexts, where independent learning is closely linked to workplace readiness.

These findings are consistent with the principles of Self-Determination Theory, which emphasise autonomy and competence as key drivers of intrinsic motivation (Ryan & Deci, 2020). Furthermore, the results support previous studies indicating that well-designed digital modules can enhance learner engagement and reduce barriers in mastering complex technical content (Alammary, 2019; Hussin et al., 2021).

Overall, the findings suggest that the module functions not only as an instructional tool but also as an effective mechanism for enhancing learning interest among TVET students.

Relationship between Module Content Perceptions and Students’ Learning Interest

Pearson correlation analysis revealed a strong, statistically significant positive relationship between students’ perceptions of the module content and their learning interest (r = 0.736, p < 0.001). This indicates that the module has been developed with clear, engaging, and relevant content, and implemented in ways that align with Kolb’s experiential cycle, students are more likely to sustain learning interest.

Table 5 Pearson Correlation Between Perception and Learning Interest

Variable	r	Interpretation	Relationship Strength
Perception & Interest	0.736	Positive	Very Strong

This finding suggests that when the module is developed with clear, engaging, and relevant content, and aligned with Kolb’s experiential learning cycle, students are more likely to sustain learning interest. The strength of this relationship highlights the critical role of instructional quality in shaping students’ learning experiences in technical education.

Rather than functioning independently, students’ perceptions and learning interest appear to be closely interconnected. Improvements in instructional design directly contribute to enhanced engagement, suggesting

that well-designed digital modules can serve as effective tools for motivating learners in complex technical subjects.

These findings are consistent with prior research demonstrating that high-quality instructional design enhances engagement and autonomy in technical learning environments (Kebritchi et al., 2017; Alammery, 2019). They also align with Zhang and Han (2022), who emphasise that visually supportive and interactive content strengthens student engagement and learning experience.

Furthermore, the results support Pamungkas et al. (2019), who reported that experiential learning approaches improve cognitive, psychomotor, and affective outcomes in vocational education. This suggests that the strong relationship observed in this study is influenced by the integration of experiential learning elements within the module, which facilitate meaningful engagement through practical application.

Strengthening learning interest is particularly important, as it is associated with deeper cognitive engagement, persistence in challenging tasks, and effective skill transfer to workplace contexts (Schunk et al., 2014; Ainley & Ainley, 2011). In the context of Industry 4.0, sustained learning interest is essential to ensure that TVET graduates remain adaptable and motivated to continuously develop their competencies (Müller, 2021; UNESCO-UNEVOC, 2020).

Limitations and Future Directions

While this study provides valuable insights, several limitations should be acknowledged. First, the study relies on self-reported data, which may not fully reflect actual skill acquisition or performance improvement in CAD/CAM applications. Students' perceptions, although important, may not accurately represent their technical competency.

Second, the study was conducted within a single institutional context, which limits the generalisability of the findings. Therefore, the results should be interpreted as preliminary and exploratory.

Future research should incorporate performance-based assessments, such as practical task evaluation, simulation accuracy, or competency-based testing, to provide a more comprehensive measure of learning effectiveness. Integrating objective performance indicators would strengthen the validity of the findings and provide a more robust evaluation of the module's impact on technical skill development.

In addition, future studies should involve larger samples across multiple institutions to enhance the robustness and external validity of the findings across diverse TVET contexts.

CONCLUSION

The development and evaluation of the digital CAD/CAM learning module in this study demonstrate the value of combining systematic instructional design with experiential learning principles in TVET education. Using the ADDIE instructional design model provided a structured pathway for analysing learners' needs, designing targeted multimedia content, and ensuring that the module was pedagogically coherent. Embedding Kolb's Experiential Learning Cycle within the module's activities ensured that students progressed through authentic experiences, reflective observation, conceptual understanding, and practical application thus promoting essential stages required for mastering complex technical skills in industrial machining technology.

The findings show that students responded positively to the module's multimedia features, structured video tutorials, and targeted Mastercam exercises, reporting high levels of engagement, confidence, and independent learning. The strong, statistically significant correlation ($r = 0.736$, $p < 0.001$) between students' perceptions and their learning interest underscores the importance of high-quality instructional design in sustaining motivation and competence development in TVET.

This integrated approach has important implications for modernising technical education. Digital modules designed through ADDIE instructional design model, while simultaneously embedding experiential learning cycles, can not only improve engagement and skill mastery but also foster the self-directed learning behaviours

required in Industry 4.0 contexts. Future research should explore the application of this research conceptual framework in other technical disciplines, assess its long-term effects on academic performance and workplace readiness, and integrate performance-based assessments to complement self-reported learning interest. Lastly, future research should expand the scope of this study by involving participants from multiple institutions to enhance the generalisability and external validity of the findings across diverse TVET contexts.

Implications for Practice

The findings of this study have several practical implications for TVET educators, curriculum designers, and instructional technologists. First, the integration of digital multimedia elements with Kolb's Experiential Learning Cycle offers a practical framework for developing digital learning modules that are both pedagogically sound and aligned with the experiential nature of technical training. By systematically analysing learner needs, designing with multimedia principles, and embedding authentic, hands-on activities, instructors can create resources that sustain engagement and build competence in complex technical subjects such as CNC machining simulation.

Second, the use of structured video tutorials, targeted exercises, and reflective activities within the module demonstrates that digital learning tools can effectively supplement in some cases, could enhance traditional workshop-based instruction. This is particularly relevant for skills-based disciplines where access to physical equipment may be limited.

Finally, the strong positive correlation between students' perceptions of module quality and their learning interest underscores the importance of continuous evaluation and refinement. Educators should treat digital module development as an iterative process, incorporating learner feedback to optimise both the technical content and the experiential learning components. This approach ensures that modules remain relevant, motivating, and effective in preparing TVET graduates for Industry 4.0 demands.

ACKNOWLEDGEMENT

This research was supported by Universiti Tun Hussein Onn Malaysia (UTHM) through GPPS (Vot J068).

Conflict of Interest

The authors declare that there are no conflicts of interest relating to the publishing of this paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Amin-Nul Aiman Anuar, Reyanhealme Rohanai; **data collection:** Amin-Nul Aiman Anuar; **analysis and interpretation of results:** Amin-Nul Aiman Anuar, Reyanhealme Rohanai, Nurhayati Baharudin; **draft manuscript preparation:** Amin-Nul Aiman Anuar, Muhammad Mohamed Saleh, Nor Hidayah Hamdan

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