INTERNATIONAL JOURNAL OF HUMANITIES TECHNOLOGY AND CIVILIZATION
E-ISSN: 2600-8815
VOLUME 11, ISSUE 2, 2026, 234 - 247
DOI: https://doi.org/10.15282/ijhtc.v11i2.14067

RESEARCH ARTICLE

The impacts of language-related challenges on student performance: The moderating role of technology-enhanced online learning features

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Abstract: Students from non-English-speaking backgrounds frequently encounter difficulties understanding learning materials, interpreting technical and complex terminology, and communicating effectively in academic discussions. These language-related challenges may lead to misunderstandings and hinder student performance. This study aims to examine the impact of language-related challenges on student performance and the moderating role of technology-enhanced online learning (TEOL) features. A quantitative cross-sectional survey design was employed. Data were collected through a structured questionnaire from 181 Business and Management students aged 20—24 at UCYP University, Malaysia. Data were analyzed using SPSS through regression and correlation analyses. The results indicate that communication is the most influential predictor of student performance ($\beta = 0.578$, $p < 0.001$), followed by technical language ($\beta = 0.155$, $p < 0.05$), whereas comprehension has no significant effect ($\beta = 0.072$, $p > 0.05$). Furthermore, TEOL features significantly moderate only the relationship between communication and student performance, with no moderating effects observed for comprehension and technical language. These findings highlight the critical role of communication in shaping student performance and suggest that TEOL features are particularly effective in supporting communication-related challenges. The study provides practical insights for higher education institutions to design targeted learning support strategies and enhance student learning outcomes.

Article History
Received : 11 February 2026
Revised : 16 April 2026
Accepted : 24 September 2026
Published : 10 November 2026

Keywords
Technology-enhanced online learning
Student performance
Language challenge

1. Introduction

Language proficiency plays a critical role in determining students' ability to understand instructional content and actively participate in learning activities. For students from non-English-speaking backgrounds, proficiency in English as the primary medium of instruction is essential for academic success at the tertiary level. However, many of these students experience significant difficulties in comprehending learning materials, interpreting technical terminology, and communicating effectively in academic settings. These challenges may lead to misunderstandings, reduced participation, and ultimately lower academic performance. The issue becomes more critical in technology-enhanced online learning environments, where students rely heavily on digital content, self-directed learning resources, and technology-mediated communication. Without sufficient language proficiency, students may struggle to navigate course materials, interact with peers and instructors, and fully utilize digital learning platforms, thereby affecting their overall learning experience and outcomes. At the global level, education reports highlight the urgency of addressing language-related challenges in learning. According to UNESCO (2022), more than 40% of the global population does not have access to education in a language they speak or understand well, which directly affects learning outcomes. Similarly, the World Bank (2020) emphasized that students in multilingual or non-native language contexts are at higher risk of lower academic achievement unless supported by inclusive learning technologies. In addition, prior studies have shown that language barriers significantly influence student engagement and persistence in online learning environments (OECD, 2021).

In response to the advancement of technology in education, higher education institutions have increasingly adopted technology-enhanced online learning (TEOL) to improve accessibility, flexibility, and learning effectiveness. TEOL encompasses various digital tools and platforms that support diverse learning needs and enable students to learn across different locations, times, and modes, including fully online and hybrid environments. These developments suggest that TEOL has the potential to address some of the challenges faced by students in modern learning contexts. Despite the widespread adoption of TEOL, limited studies have specifically examined how its features can mitigate language-related challenges in influencing student performance. Existing research tends to focus on either language barriers or technology-enhanced learning independently, with less attention given to their combined effects. In particular, there is a lack of empirical evidence on how TEOL features function as a moderating mechanism in shaping the relationship between language-related challenges and student performance. Therefore, this study aims to examine the impact of language-related challenges, namely comprehension, technical language, and communication on student performance, as well as the moderating role of Technology-Enhanced Online Learning (TEOL) features. By integrating language-related factors with technology-enhanced learning environments, systems can support students in overcoming language-related barriers and improving academic outcomes.

The rise of digital tools and online platforms has significantly transformed educational delivery, enabling greater accessibility, flexibility, and interactivity in learning environments. Language-related challenges remain a significant issue in higher education, particularly in technology-enhanced online learning environments. Among these challenges,

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three key aspects are often highlighted: Students from non-English-speaking backgrounds often face comprehension difficulties in understanding instructional materials. Secondly, the technical language (Feng, He, et. all, 2023) barriers, which arise from the use of specialized or complex terminology (Muhammadi et. all, 2024, Malakul and Park, 2024), and effective communication (Chishiba and Joseph, 2024, Hamad and Seyyedi, 2020) challenges, may negatively affect their academic performance. Previous studies have examined the direct effects of language barriers on student performance and the role of technology in enhancing learning experiences. However, these studies have largely treated language-related challenges and technology-enhanced learning as separate constructs. Limited attention has been given to how Technology-Enhanced Online Learning (TEOL) features function as a moderating mechanism in shaping the relationship between language-related challenges and student performance. This gap is particularly evident in higher education contexts, where students are required to engage with complex academic content and technology-mediated learning environments. Understanding the moderating role of TEOL features is therefore essential to determine whether and how technological support can alleviate the negative impact of language-related challenges on student performance.

1.1 Research Objective

The main objectives of this research are the following:

i. To investigate the relationship between comprehension and student performance.
ii. To investigate the relationship between technical language and student performance.
iii. To investigate the relationship between communication and student performance.
iv. To examine which language-related challenges most affect student performance.
v. To determine whether technology-enhanced online learning features moderate the relationships between these language-related challenges and student performance

1.2 Research Question

The research will answer the following questions:

i. Is there any relationship between comprehension and student performance?
ii. Is there any relationship between technical language and student performance?
iii. Is there any relationship between communication and student performance?
iv. Which language-related challenges most affect the student performance?
v. To what extent do technology-enhanced online learning features moderate the relationships between these language-related challenges and student performance?

2. Literature Review

2.1 Student Performance

Language differences are not necessarily seen as entirely detrimental to student performance; instead, they have been shown to result in a range of outcomes. Teaching materials can enhance comprehension, foster critical thinking, and promote student success in academics (Yunus et al., 2024). Beyond language, student performance is also shaped by motivation, cognitive ability, and access to supportive learning environments. Studies suggest that when students are given adequate resources, guidance, and technology integration, they are more capable of overcoming barriers and achieving academic success. Thus, performance should be seen as an outcome influenced by both student-related and environment-related factors. In the context of online and technology-mediated learning, student performance has increasingly been linked to the ability to navigate digital platforms and overcome learning obstacles, including language barriers. Research indicates that effective use of educational technologies not only improves accessibility but also enhances comprehension and engagement, which are critical for performance outcomes (OECD, 2021; UNESCO, 2022). Accordingly, this study positions student performance as the dependent variable shaped by language-related challenges while being potentially moderated by the features of Technology-Enhanced Online Learning (TEOL).

2.2 Language-Related Challenges

Language-related challenges represent a multidimensional barrier that shapes how students interpret, process, and apply academic knowledge. These challenges are not confined to simple communication difficulties, they directly influence comprehension, mastery of subject-specific terminology, and the ability to engage in collaborative learning. Many non-native English speakers or foreign language learners fail to use learning materials that are written in English (Yunus et all., 2024). In higher education, three dimensions are particularly critical which refers to comprehension difficulties, technical language barriers, and communication constraints. Comprehension difficulties arise when students encounter instructional materials in a language in which they lack proficiency. This increases cognitive load, often leading to misinterpretation of concepts and reduced ability to follow instructions accurately. Technical language barriers add another layer of complexity, as discipline-specific terminology and academic jargon demand specialized knowledge that non-native speakers may struggle to acquire. Communication challenges further compound the issue, limiting students' confidence and participation in discussions, peer collaboration, and interaction with instructors, which are activities that are essential for active learning and academic success.

While these challenges can undermine performance, they also carry developmental potential. Engaging with academic content in a second language has been shown to foster adaptability, intercultural competence, and higher-order thinking skills. This dual nature highlights the importance of supportive mechanisms that can reduce the negative impact while amplifying the benefits. In this regard, Technology-Enhanced Online Learning (TEOL) offers a promising moderating

role. Features such as multimedia resources, translation tools, and interactive communication platforms can help students overcome comprehension gaps, navigate technical terminology more effectively, and engage in collaborative learning with greater confidence. By providing technological scaffolding, TEOL has the potential to transform language-related challenges from obstacles into opportunities for growth, thereby justifying its inclusion as a moderating variable in this study.

2.3 Comprehension

According to Yunus (2024), teaching materials supposedly can enhance comprehension. Comprehension is a fundamental cognitive skill that determines how effectively students can process and internalize academic content. It encompasses both reading comprehension that refers to understanding written texts, instructions, and notes, and listening comprehension, which involves interpreting spoken lectures, group discussions, and multimedia content. When comprehension is limited, students face increased cognitive load, which often results in misinterpretation of concepts, inaccurate responses to exam questions, and reduced ability to follow complex instructions. These difficulties directly undermine academic performance, particularly in higher education where precision and speed are essential. International students frequently encounter layered challenges that hinder comprehension, including unfamiliar vocabulary, complex grammatical structures, and limited cultural context (Al-Jarrah et al., 2018; Hassan et al., 2021). Such barriers slow reading speed, reduce retention, and heighten anxiety, all of which negatively affect learning outcomes. Listening comprehension presents additional obstacles, as differences in accents, rapid speech delivery, and limited exposure to academic discourse can further restrict understanding. Vasquez Diaz & Iqbal (2024) investigated comprehension of native-speaker accents through a mixed-methods study. They found that 42 % of participants cited accent differences as the greatest obstacle to understanding spoken English, followed by fast speech delivery. These factors collectively explain why comprehension difficulties are consistently associated with lower academic achievement.

The relationship between comprehension and student performance is therefore theoretically justified, where comprehension acts as the gateway to knowledge acquisition, and any disruption in this process directly impacts learning outcomes. Empirical evidence supports this mechanism, showing that grammatical knowledge, vocabulary mastery, and decoding skills strongly predict comprehension levels, which in turn correlate with academic success across disciplines. A comprehensive meta-analysis (Zheng, et al.,2023) reviewed 86 empirical studies (14,852 readers, primary to tertiary level). It concluded that grammatical knowledge shows a strong positive correlation with reading comprehension, especially across different grade levels and text genres. Technology-Enhanced Online Learning (TEOL) features may moderate this relationship by providing scaffolding that reduces cognitive strain. Multimedia resources, interactive simulations, and adaptive feedback can help students clarify meaning, visualize abstract concepts, and revisit content at their own pace. Translation tools and captioning functions further support listening comprehension by minimizing the impact of accent differences and fast speech. By offering these technological supports, TEOL has the potential to weaken the negative link between poor comprehension and low performance, thereby enabling students to engage more effectively with academic content.

2.4 Technical Language

Technical language refers to the discipline-specific vocabulary, symbols, and expressions that are central to academic and professional fields. Unlike general language proficiency, mastery of technical terminology is essential for students to decode subject matter, follow lectures, and produce accurate written work. When students lack familiarity with this specialized lexicon, they struggle to grasp concepts, misinterpret instructions, and face difficulties in applying knowledge to assessments. These challenges affect both comprehension and production, making technical language a critical determinant of academic performance. Specialist vocabulary functions as a gateway to disciplinary knowledge. Research consistently shows that technical terms contribute uniquely to academic success, even when general vocabulary knowledge is controlled (Masrai et al, 2021). A systematic review of English-medium instruction (EMI) studies also identifies vocabulary knowledge (both general and specialist) as a consistent predictor of student success, and highlights that many prior studies have not examined situational moderators (e.g., instructional technologies or supports) that might alter vocabulary's impact on outcomes. (Feng et al., 2023).

This is because technical language carries precise meanings that cannot be substituted by general words. Students who fail to master these terms are unable to fully participate in disciplinary literacy practices such as reading scholarly texts, writing structured assignments, or engaging in professional discourse. From a theoretical perspective, disciplinary literacy emphasizes that learning involves acquiring the ways of reading, writing, and speaking specific to each field. Without access to these conventions, students remain excluded from the deeper cognitive and communicative practices of their discipline. Research on disciplinary literacy emphasizes that students need scaffolds and equitable access to the ways of reading, writing, and speaking specific to each discipline; these literacy practices (including teaching of technical terms and genre conventions) are central to enabling students to participate and perform in assessments. (Waymouth & Hinchman, 2025).

Cognitive load theory provides further explanation of why technical language produces difficulty. Dense terminology and abstract notations increase intrinsic and extraneous cognitive load, leaving fewer cognitive resources available for problem solving and conceptual integration. For learners with weaker language skills, this overload results in fragmented understanding and poor retention. Classroom studies confirm that instructional supports such as captioned videos, annotated diagrams, and step-by-step worked examples reduce cognitive strain and improve comprehension, particularly for non-native speakers. These findings highlight that technical language barriers directly weaken student performance

by limiting both understanding and application of disciplinary content. Together, these findings support the idea that well-designed instructional supports can reduce the negative influence of specialist vocabulary by lowering extraneous processing demands (Malakul & Park, 2023). Empirical evidence also demonstrates the importance of specialist vocabulary in predicting academic outcomes. Vocabulary assessment instruments that distinguish between general, academic, and specialist knowledge show that discipline-specific terms make a measurable contribution to performance beyond general vocabulary. Students with stronger technical vocabulary consistently achieve higher grades, while those with weaker skills face persistent disadvantages in assessments and collaborative tasks. Disciplinary literacy research therefore emphasizes instructional scaffolds (explicit vocabulary teaching, annotated texts, genre instruction) that make the cognitive demands of the discipline more transparent and teachable (Ferguson & Scanlon, 2024). This evidence justifies positioning technical language as an independent variable that significantly influences student performance. A 2024 quasi-experimental study by Hossein et al. (as summarized in *Heliyon*) examined mobile-assisted learning using digital flashcards. University students exposed to digital flashcards showed significantly greater improvements in both receptive and productive academic vocabulary than peers using traditional methods, highlighting the benefit of tech-mediated interventions in vocabulary acquisition.

Masrai and colleagues (2021) developed and validated three vocabulary assessment instruments which are General Vocabulary Size Test (GVST), Academic Vocabulary Size Test (AVST), and Business/ Specialist Vocabulary Size Test (BVST) to differentiate between general, academic, and specialist vocabulary knowledge. They found that these tests are highly reliable (Cronbach's α values > .95), and that specialist vocabulary (BVST) has a measurable, though modest, unique contribution to academic performance beyond general and academic vocabulary. The instruments help operationalizes technical-language difficulty by quantifying students' mastery of discipline-specific terms distinct from general vocabulary (Masrai et al., 2021). A growing body of research examines technology-mediated supports for vocabulary and content learning. Meta-analyses and reviews show that captioned and subtitled videos tend to enhance vocabulary acquisition and comprehension (particularly for second-language learners or when captions are in the learner's language), that mobile-assisted digital flashcards produce larger gains in both receptive and productive academic vocabulary than traditional methods, and that adaptive tutoring systems can personalize practice to learner needs and thereby accelerate vocabulary learning.

Technology-Enhanced Online Learning (TEOL) features may moderate this relationship by reducing the cognitive burden associated with technical language. Digital glossaries and captioned videos provide immediate clarification of unfamiliar terms, while annotated diagrams and interactive simulations help students visualize abstract concepts. Mobile-assisted tools such as digital flashcards accelerate vocabulary acquisition and improve self-efficacy, and adaptive tutoring systems personalize practice to learner needs, thereby strengthening retention. Meta-analyses further show that technology-mediated supports operate through distinct mechanisms such as multimedia redundancy, retrieval practice, and adaptive feedback, suggesting that their effects on specialist vocabulary are feature-specific rather than uniform (Reynolds, 2022). By offering these supports, TEOL can weaken the negative impact of technical language difficulties, enabling students to engage more effectively with disciplinary content and perform at higher levels.

2.5 Communication

Communication is a central component of academic success, as it enables students to exchange ideas, clarify understanding, and actively participate in collaborative learning. In higher education, communication challenges often arise when students lack confidence in expressing themselves, face difficulties in academic writing, or struggle with oral participation in discussions and presentations. These barriers reduce engagement, limit peer interaction, and weaken the feedback loop between students and instructors. As a result, communication difficulties directly undermine student performance by restricting opportunities for active learning and knowledge construction. Empirical studies consistently highlight the negative impact of weak communication skills on academic outcomes. Students who experience public speaking anxiety or presentation apprehension often withdraw from classroom participation, missing critical opportunities to practice and refine their understanding. A systematic review examining first-year students reveals recurring communication obstacles that indicate clear links between communication challenges and diminished academic outcomes (Chishiba and Joseph, 2024). Similarly, difficulties in academic writing prevent students from articulating ideas clearly, leading to lower assessment scores. Cultural and linguistic differences further compound these challenges, as international students may face additional obstacles in adapting to unfamiliar discourse conventions. These factors collectively explain why communication barriers are strongly associated with reduced motivation, diminished engagement, and weaker academic achievement.

Theoretically, communication can be understood as both a cognitive and a social process. Effective communication requires not only linguistic proficiency but also the ability to interpret context, manage anxiety, and engage in reciprocal interaction. When these elements are disrupted, students experience isolation and reduced confidence, which in turn affects persistence and performance. Communication breakdowns also hinder collaborative learning, where knowledge is co-constructed through dialogue and peer exchange. Without effective communication, students are unable to fully benefit from group work, discussions, or instructor feedback, thereby limiting their academic growth. Belozerova (2021) found that young people are now more likely to get information from the internet instead of through real conversations. This reduces the need for personal interaction. Another issue is the lack of connection with nature, which plays an emotional role in communication. Nature helps people relax, feel energized, and reflect, but many students today are missing this experience. All these factors create barriers to effective communication among young people. Bello and Agyeman (2023) highlight that language and cultural barriers are key factors affecting the academic success of BAME

and international students in the UK. Based on their findings, they recommend that universities provide better language support services. They also suggest offering programs to help students adapt to cultural differences. These steps can reduce communication challenges and improve student performance.

Technology-Enhanced Online Learning (TEOL) features may moderate the relationship between communication challenges and student performance by providing alternative channels for interaction. Real-time tools such as live chat and video conferencing can reduce barriers to participation by allowing students to engage at their own pace and in less intimidating formats (Fabriz et al., 2021). Asynchronous platforms, including discussion boards and collaborative documents, offer opportunities for reflection and structured communication, which can alleviate anxiety associated with immediate responses. Multimedia resources, captioning, and translation tools further support students in overcoming linguistic and cultural barriers, enabling them to engage more confidently in academic discourse. Salarvand et al (2023) explore how virtual learning during the COVID-19 era posed significant communication obstacles specifically, one-way feedback, weak two-way communication, diminished interaction, and inadequate feedback which led to reduced student engagement, motivation, and academic effectiveness. It also highlights infrastructural issues like poor internet access and limited resources that further magnified communication breakdowns and negatively affected learning outcomes.

On the other hand, by offering diverse modes of interaction today, TEOL has the potential to transform communication challenges into opportunities for engagement. Many students struggle to speak English. About 40% said they face this problem both inside and outside the classroom. The study found that speaking challenges are caused by connected issues. These include psychological, language-related, and cultural factors. One problem often leads to another, making the situation worse. These difficulties create a cycle that affects students' ability to speak (Hamad & Seyyedi, 2020). Students who struggle with oral participation may find written or asynchronous formats more accessible, while those facing linguistic barriers can benefit from translation and captioning features. These supports not only reduce the negative impact of communication difficulties but also enhance inclusivity, ensuring that students from diverse backgrounds can participate meaningfully in academic activities. Accordingly, TEOL is positioned as a moderating variable that can weaken the adverse effects of communication challenges on student performance and foster more equitable learning outcomes.

2.6 Technology-Enhanced Online Learning Features

Technology has long been integrated into education, but its role has evolved significantly over the past decades. Early adoption in countries such as the United States demonstrated how online platforms could expand access to learning, and subsequent innovations have transformed technology from a simple delivery mechanism into a comprehensive ecosystem of interactive tools (Zhou & Zhang, 2022). Today, Technology-Enhanced Online Learning (TEOL) encompasses learning management systems, multimedia resources, gamification, mobile applications, and collaborative digital platforms (Choi-Lundberg, 2023). These features make learning more accessible, flexible, and engaging for students across different disciplines and regions. By offering personalization, interactivity, and multimedia support, TEOL helps address various learning needs and styles.

Beyond general benefits, TEOL features play a crucial role in addressing language-related barriers that hinder student performance. Interactive captions and translation tools help students overcome comprehension difficulties by clarifying meaning and reducing misinterpretation. Multimedia explanations and annotated resources support the decoding of technical terminology, while asynchronous discussion forums and collaborative platforms provide safe spaces for communication practice. These supports are particularly valuable for students from non-native language backgrounds, who often face challenges in understanding complex content and participating confidently in academic discourse. The moderating role of TEOL is theoretically justified. Language proficiency alone does not fully determine academic success, its impact varies depending on the level of technological support available. When TEOL features are integrated effectively, they can buffer the negative effects of comprehension difficulties, technical language barriers, and communication challenges. For example, captioned videos reduce cognitive load by reinforcing auditory input with visual text, while adaptive feedback systems personalize learning to individual needs, thereby enhancing retention and confidence. In this way, TEOL does not simply supplement instruction but actively reshapes the relationship between language-related challenges and student performance.

In this study, TEOL is therefore conceptualized as a moderator that influences the strength and direction of the relationship between language-related challenges and academic outcomes. By providing scaffolding, personalization, and alternative modes of interaction, TEOL has the potential to transform language barriers from obstacles into manageable challenges. This perspective highlights the importance of examining not only the direct effects of language proficiency on performance but also the conditions under which technological support can amplify or diminish those effects.

2.7 Theories

This study is underpinned by two theoretical perspectives, namely the Stimulus–Organism–Response (S-O-R) framework and the Theory of Planned Behavior (TPB). The S-O-R framework, initially developed in environmental psychology, posits that individuals' behavior is influenced by external stimuli, which shape internal processes and eventually produce a response (Mehrabian & Russell, 1974). In the context of education, stimuli represent external learning factors, the organism reflects learners' internal cognitive and emotional states, and the response denotes observable learning outcomes such as performance.

According to the S-O-R model, language-related challenges such as comprehension difficulties, technical language barriers, and communication challenges serve as stimuli that affect learners' perceptions and emotions (organism). These

internal states, in turn, influence their academic outcomes (response). The model also accommodates the role of moderators, in this case, Technology-Enhanced Online Learning (TEOL) features, which may alter the strength or direction of the relationship between challenges and performance. For example, high interactivity and accessibility in TEOL systems can reduce the negative impact of language difficulties on student learning outcomes. Complementing this framework, the Theory of Planned Behavior (TPB) (Ajzen, 1991) provides a psychological lens to understand students' academic behaviors. TPB emphasizes three core constructs: attitude toward the behavior, subjective norms, and perceived behavioral control. In online learning environments, students' attitudes toward using technology, the perceived expectations of peers and instructors (subjective norms), and their confidence in overcoming learning barriers (perceived control) shape their academic behaviors and outcomes. Language-related challenges can negatively affect perceived control and attitudes, leading to weaker academic performance. However, when TEOL features provide adequate support—such as clear content, translation tools, and interactive platforms—students' perceived control is enhanced, thereby mitigating the adverse effects of language barriers.

The integration of S-O-R and TPB is particularly relevant for this study. While S-O-R offers a broad structure linking external challenges (stimuli), internal perceptions (organism), and academic outcomes (response), TPB explains the mechanisms within the organism by detailing how attitudes, norms, and perceived control influence students' performance. Past studies have successfully applied these frameworks in online education, showing that technology adoption and learning outcomes are shaped by both environmental stimuli and individual psychological factors (Zhou & Zhang, 2022; Yunus et al., 2024). Together, these theories provide a comprehensive foundation to investigate how language-related challenges influence student performance and how TEOL features can moderate these relationships.

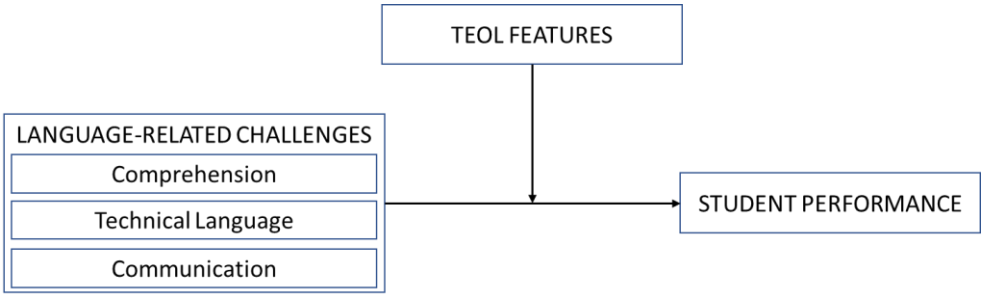
Table 1

Theories and their application

Theory	Core Components	Relevance to Study	Application in Current Research
Stimulus–Organism–Response (S-O-R) (Mehrabian & Russell, 1974)	i. Stimulus (S): External factors (e.g., comprehension difficulties, technical language barriers, communication challenges). ii. Organism (O): Internal states (e.g., perceptions, attitudes, cognitive responses). iii. Response (R): Behavioral outcomes (e.g., student performance).	Explains how external challenges (language-related) influence internal perceptions and ultimately affect learning outcomes.	i. Language-related challenges = Stimuli. - Students' perceptions/engagement = Organism. - Student performance = Response. ii. TEOL features moderate the link between stimuli and response.
Theory of Planned Behavior (TPB) (Ajzen, 1991)	i. Attitude: Positive/negative evaluation of learning in online settings. ii. Subjective Norms: Influence of peers, instructors, institutional expectations. iii. Perceived Behavioral Control: Confidence in overcoming language and technology barriers.	Explains how students' beliefs, attitudes, and perceived control affect their learning behaviors and academic performance.	i. Language challenges lower perceived control and attitudes. ii. TEOL features improve perceived control, thereby mitigating negative effects. iii. Student performance reflects behavioral outcomes influenced by TPB constructs.

Figure 1

Conceptual framework



3. Research Methodology

3.1 Research Design

This study adopted a quantitative, cross-sectional survey, correlational design, which is appropriate for examining statistical relationships between variables. Furthermore, for moderation analysis, the analysis of PROCESS by Hayes was conducted. The purpose of this is to determine whether a moderator variable affects the direction or strength of the relationship between an independent and dependent variable. According to Creswell and Creswell (2018), these are suitable for analyzing correlations between variables and acquiring quantifiable, statistically analyzable data. This is to

evaluate the moderating effect of Technology-Enhanced Online Learning (TEOL) features on the relationship between the impacts of language-related challenges on student performance.

3.2 Sampling Method

This study employed a simple random sampling technique to select respondents from the population of degree program students at UCYP University. Simple random sampling minimizes selection bias and ensures that every individual in the population has an equal probability of being selected (Lee, 2025). To operationalize this method, a complete list of 347 degree students was obtained from the university registry. Each student was assigned a unique identification number, and a random number generator was used to select the required sample which included local and international students. Based on the sample size determination Krejcie and Morgan (1970), a minimum sample of 181 respondents is required for a population of 347. Therefore, 181 students were randomly selected as the study sample. Degree program students are a highly relevant demographic for studying language-related learning challenges as they are required to interact with the academic resources, assessments and evaluations in foreign languages (Tran & Pham, 2022). Additionally, degree students are more likely to have a lot of experience with technology-mediated learning settings especially after the COVID-19 epidemic. That's the era when the online learning platforms have become an essential for the delivery of higher education institutions (Adedoyin & Soykan, 2023). They are therefore a suitable cohort to investigate how TEOL features moderate performance outcomes.

3.3 Data Collection Process

The data for this study were collected through a self-administered survey questionnaire which is designed in dual languages that consists of English and Bahasa Malaysia. This is to ensure clarity and inclusivity for all respondents. The questionnaire comprised 32 items measured on a five-point Likert scale, ranging from strongly disagree (1) to strongly agree (5), which is widely used for assessing attitudes, perceptions, and behaviors (Rokeman and Kob, 2023). Google Forms was used to develop and distribute the questionnaire. It makes it easy for respondents to complete it online (Rayhan et al., 2022). To ensure that only UCYP degree program students may participate, the link to the form was sent directly to the chosen participants through institutional communication channels. A total of 181 valid responses were collected, resulting in a 100% response rate from the respondents for survey research.

3.4 Questionnaire Structure

The questionnaire consisted of closed-ended questions to systematically assess various aspects of language-related challenges. The key area covered in the survey included four parts. The questionnaire consisted of four sections: (A) Demographics, (B) Language-Related Challenges (Comprehension, Technical Language, and Communication), (C) Student Performance, and (D) Technology-Enhanced Online Learning (TEOL) Features. By using structured, closed-ended questions, the study ensured that responses could be easily quantified and analyzed statistically, leading to more accurate conclusions. There are 32 items from the questionnaire in this study were adopted and adapted from several established studies related to language comprehension, communication skills, online learning, academic performance, and technology-enhanced learning environments (Ariffin et al., 2021; Wang et al., 2020; Osman et al., 2022; Kohnke & Jarvis, 2023; Abdul Rahim et al., 2022; Rameli et al., 2023; Yusoff & Seman, 2025).

3.5 Data Analysis

The collected responses of 181 participants were analyzed using Statistical Package for the Social Sciences (SPSS). The study employed descriptive statistical methods. There are several data analysis methods adopted in this study which are correlation analysis, multiple regression analysis and moderation analysis using PROCESS by Hayes. Pearson correlation analysis was conducted to examine the strength and direction of the relationship between language-related challenges and student performance. The analysis helps determine whether the variables are positively or negatively related and the degree of association between them (Hair et al., 2021). Meanwhile, the multiple regression analysis was used to determine the extent to which the independent variables would predict the dependent variables. This analysis evaluates the contribution of language-related challenges toward the student performance. The regression coefficients, significance values, and coefficient of determination (R^2) were examined to assess the predictive power of the model (Babin et al., 2022). On the other hand, the research objective is to determine whether technology-enhanced online learning features moderate the relationships between these language-related challenges and student performance, moderation analysis using PROCESS by Hayes. This analysis was adopted to examine the moderating effect of TEOL features on the relationship between language-related challenges and student performance (Hayes, 2022). This is to determine whether TEOL features significantly influence the relationship between language-related challenges and student performance.

3.6 Ethical Statement

Ethical considerations were prioritized throughout the research process to ensure the protection of participants' rights and privacy. For this study, there was voluntary participation from the respondents where they are free to participate or withdraw at any time without any consequences. All respondents provided their consent before completing the questionnaire since they were informed about the goal of the study and how their replies would be utilised. This is to ensure research transparency and uphold the highest standards of academic integrity and research ethics.

4. Results

4.1 Respondent's Demographics

The survey involved 181 respondents, where most were aged 20–24 years (49.2%), female (58.0%), and studying Business and Management (59.1%). The majority of the respondents were from Malaysia (90.6%), with Malay language as their first language (82.3%) and English as the main language in online courses (61.9%). Most rated their language proficiency as good (54.7%) and attended online classes occasionally (40.9%). While 41.4% had occasional access to online learning features, 48.1% had used online platforms for more than two years.

4.2 Reliability Analysis

The To proceed the study with further analysis, all instruments of language-related challenges and student performance have to be at high reliability.

Table 2

Reliability analysis

Variable	No of items	Cronbach's Alpha	Descriptions
Comprehension	6	.911	Excellent
Technical Language	7	.917	Excellent
Communication	6	.931	Excellent
Student Performance	7	.900	Excellent
Technology-Enhanced Online Learning (TEOL)	6	.939	Excellent
Technical Language	7	.917	Excellent

Table 2 shows the results of the reliability analysis in a preliminary test that was conducted to assess the consistency of the instruments used in the study. Based on the table, all constructs demonstrated excellent reliability (α ranging from .900 to .939), exceeding the recommended threshold of 0.70, indicating high internal consistency of the measurement items.

4.3 Correlation Analysis

The study used a bivariate correlation test to measure an association between one variable to the student performance in a linear fashion. The results in Table 3 indicate significant correlations between language-related challenges and student performance ($r = .596$ to $.742$, $p < .001$). This suggests that students who report higher scores in language-related challenges tend to show corresponding differences in performance, highlighting the importance of examining this relationship further through regression and moderation analyses.

Table 3

Correlations analysis

Variables	Pearson Correlation	Sig.
Comprehension	.596**	.000
Technical Language	.622**	.000
Communication	.742**	.000

4.4 Multiple Regression Analysis

After the independent variables are correlated with one another and with the dependent variable, the regression analysis may take the next stage. To examine the most language-related variable affecting the student's performance, the study uses multiple regression equations to identify the prediction. The regression model explained 56.8% of the variance in student performance ($R^2 = .568$), indicating that more than half of the variation in performance can be accounted for by the three predictors: comprehension difficulties, technical language barriers, and communication challenges. Among these, communication challenges emerged as the most influential predictor ($\beta = .578$, $p < .001$), suggesting that difficulties in communication significantly reduce student performance and represent the strongest barrier compared to the other two dimensions. Technical language also contributed significantly, though to a lesser extent ($\beta = .155$, $p < .05$), highlighting that the use of complex or discipline-specific terminology can hinder students' ability to perform well academically. In contrast, comprehension difficulties did not show a significant effect on performance ($\beta = .072$, $p > .05$), implying that although students may struggle to understand content, this factor alone does not directly predict their academic outcomes once communication and technical language barriers are considered. Overall, the findings emphasize that communication challenges are the primary language-related factor influencing student performance, with technical language playing a secondary role, while comprehension on its own is less critical in this context.

Table 4

Multiple regression analysis

Variables	Standardized Coefficient Beta	t	Sig.
Comprehension	.072	.945	.346
Technical Language	.155	2.044	.042
Communication	.578	7.136	.000

*R Square = .568

4.5 Moderation Analysis

The fifth objective of the research is to investigate whether the moderator variable which the TEOL features specifically moderates the relationship between the impacts of language related challenges affecting the student performance or not. To satisfy the purpose, analysis of PROCESS by Hayes was conducted. It means to test the moderator variable (TEOL features) whether it moderates the relationship between independent variable (language related challenges) and the dependent variable (students' performance) or not.

4.6 Effect of TEOL Features on Comprehension and Student Performance

Table 5 presents the model summary for the moderation analysis. The results indicate an R value of 0.6737 and an R^2 value of 0.4539. This means that approximately 45.39% of the variance in student performance is explained by the combined effects of comprehension, TEOL features, and the interaction between comprehension and TEOL features. The remaining 54.61% of the variance may be explained by other factors not included in this study.

Table 5

Model summary

R	R-sq	MSE	F	df1	df2	p
.6737	.4539	12.9528	49.0315	3.0000	177.000	.0000

Table 6

Moderation analysis

Model	Coeff	se	t	p	LLCI	ULCI
Constant	22.2381	8.8526	2.5120	.0129	4.7679	39.7084
Comprehension	-.2842	.4121	-.6896	.4914	-1.0974	.5291
TEOL Features	-.1856	.3481	-.5332	.5946	-.8725	.5013
Interaction	.0274	.0156	1.7546	.0811	-.0034	.0582

The interaction effect between TEOL features and comprehension difficulties was found to be statistically insignificant ($p > .05$), indicating that TEOL features do not significantly moderate the relationship between comprehension difficulties and student performance. Although the interaction coefficient was negative, the effect was not statistically significant and therefore cannot be interpreted as a meaningful moderating effect.

4.7 Effect of TEOL Features on Technical Language and Student Performance

Table 7 presents the model summary for the moderation analysis. The results indicate an R value of 0.6882 and an R^2 value of 0.4737. This shows that approximately 47.37% of the variance in student performance is explained by the model, which includes technical language, TEOL features, and the interaction term between technical language and TEOL features. The remaining 52.63% of the variance is explained by other factors not included in this study.

Table 7

Model summary

R	R-sq	MSE	F	df1	df2	p
.6882	.4737	12.4829	53.0978	3.0000	177.0000	.0000

Table 8 presents the value of significance on the interaction between TEOL features, technical language and student performance. However, the p-value showed there is no significant interaction of TEOLS features on technical language and student performance as the p-value above 0.05. Therefore, there is no effect of TEOL features towards the relationship between technical and student performance.

Table 8

Moderation analysis

Model	Coeff	se	t	p	LLCI	ULCI
Constant	1.6275	11.0390	.1474	.8830	-20.1574	23.4124
Technical Language	.5798	.4286	1.3528	.1779	-.2660	1.4255
TEOL Features	.5185	.4231	1.2255	.2220	-.3165	1.3535
Interaction	-.0047	.0160	-.2957	.7678	-.0363	.0268

4.8 Effect of TEOL Features on Communication and Student Performance

Table 9 presents the model summary for the moderation analysis. The results indicate an R value of 0.7721 and an R^2 value of 0.5962. This means that approximately 59.62% of the variance in student performance is explained by the model, which includes communication, TEOL features, and the interaction term between communication and TEOL features. The remaining 40.38% of the variance is explained by other factors not included in this study.

Table 9

Model summary

R	R-sq	MSE	F	df1	df2	p
.7721	.5962	9.5778	87.0996	3.0000	177.0000	.0000

Table 10 presents the interaction values of the moderator variable TEOL feature on the relationship between the communication and student performance displaying the significant value as the p-value is .000 lower than 0.05. Thus, the TEOL features have positively moderated the relationship between communication and student performance. As a summary, across the three models, TEOL features only positively moderate the relationship between communication and student performance, whereas there is no moderating effect on the relationship between comprehension and technical language on student performance.

Table 10

Moderation analysis

Model	Coeff	se	t	p	LLCI	ULCI
constant	1.1983	.3517	3.4069	.0008	.50501	.8917
Communication	.6443	.1374	4.6906	.0000	.3735	.9150
TEOL Features	.7204	.0813	8.8616	.0000	.5602	.8807
Interaction	.1446	.0319	4.5336	.0000	.2075	.0817

4.9 Summary of Hypotheses

This study embarks on the following hypotheses:

H1 : There is a positive significant relationship between comprehension and student performance.
H2 : There is a positive significant relationship between technical language and student performance.
H3 : There is a positive significant relationship between communication and student performance.
H4 : Technology-Enhanced Online Learning (TEOL) features positively moderate the relationship between comprehension and student performance.
H5 : Technology-Enhanced Online Learning (TEOL) features positively moderate the relationship between technical language and student performance.
H6 : Technology-Enhanced Online Learning (TEOL) features positively moderate the relationship between communication and student performance.

The hypothesis testing results provide important insights into the relationships between language-related challenges, TEOL features, and student performance. Table11 presents the summary of all hypotheses tested in this study, including the direct relationships and moderating effects of Technology-Enhanced Online Learning (TEOL) features. The hypothesis testing results revealed that comprehension, technical language, and communication have significant relationships with student performance. Therefore, all direct relationship hypotheses were accepted. These findings indicate that language-related challenges play an important role in influencing students' academic performance. In terms of moderation, TEOL features did not significantly moderate the relationships between comprehension and student performance, as well as between technical language and student performance. Thus, both hypotheses were rejected. However, TEOL features were found to significantly moderate the relationship between communication and student performance, indicating that TEOL environments are more effective in supporting communication-related aspects of learning.

Table 11

Summary of hypotheses

Hypotheses	Results
There is a positive significant relationship between comprehension and student performance.	Accepted
There is a positive significant relationship between technical language and student performance.	Accepted
There is a positive significant relationship between communication and student performance.	Accepted
Technology-Enhanced Online Learning (TEOL) features positively moderate the relationship between comprehension and student performance.	Rejected
Technology-Enhanced Online Learning (TEOL) features positively moderate the relationship between technical language and student performance.	Rejected
Technology-Enhanced Online Learning (TEOL) features positively moderate the relationship between communication and student performance.	Accepted

5. Discussion and Interpretations

The findings of this study provide important insights into how TEOL features moderate the relationship between language-related challenges and student performance. First, comprehension difficulties showed an insignificant relationship with student performance, suggesting that comprehension difficulties did not directly predict students' academic achievement in the present study. This aligns with Yunus et al. (2024), who emphasized that comprehension skills form the foundation of academic engagement but may not independently determine academic performance when other barriers, such as linguistic complexity, are present. Second, similarly, technical language barriers displayed an insignificant relationship with student performance. This finding suggests that difficulties related to domain-specific terminology and academic vocabulary did not significantly influence students' academic achievement in the present study. Although previous studies by Masrai et al. (2021) and Zheng et al. (2023) highlighted the importance of technical language proficiency in supporting academic learning and disciplinary understanding, its direct contribution to performance may be less apparent in technology-enhanced learning environments, where students can rely on digital resources, translation tools, recorded lectures, and collaborative learning strategies to support understanding. Unlike comprehension and technical language, communication demonstrated a significant relationship with student performance. The significant role of communication mirrors the arguments by Vasque Diaz and Iqbal (2024) and Chishiba and Joseph (2024), who asserted that communicative competence underpins collaborative learning and critical thinking. In line with Stimulus-Organism-Response (SOR) model (Mehrabian & Russell, 1974), communication can be conceptualized as a stimulus that triggers cognitive and emotional responses (Organism), ultimately influencing behavioral outcomes such as academic performance (Response). Students with strong communication skills are able to express themselves clearly, share information, and participate in discussions that foster a deeper understanding of the academic subjects. Moreover, students who are able to communicate effectively contribute to creating a positive learning atmosphere in which peer interaction promotes higher-order thinking and knowledge co-construction.

Among the investigated variables, communication emerged as the most influential determinant of student performance. This finding corroborates Hassan et al. (2021), Ferguson and Scanlon (2024), who argued that communication competence mediates access to resources, peer collaboration, and academic self-efficacy. It also resonates with Ajzen's Theory of Planned Behavior (1991), wherein effective communication shapes attitudes and perceived behavioral control, both of which are pivotal for student success in learning environments. Students with strong communication skills are more likely in a better position to build positive relationships with others, have a two-way dialogue with the lecturers for further clarification and get additional academic assistance to improve their learning environment. Effective communication also encourages teamwork in group projects, conversations, and problem-solving activities, which enhances group learning and boosts academic confidence. The moderating role of technology-enhanced online learning (TEOL) features yielded mixed outcomes. While TEOL significantly strengthened the relationship between communication and student performance, it negatively moderated the effects of comprehension and technical language on performance. This duality suggests that digital platforms amplify interactive communication (e.g., discussion forums, collaborative tools) but potentially contributes to situation where the students struggle with comprehension or technical jargon, echoing the concerns raised by Al Jarrah et al. (2018) and Fabriz et al. (2021). Zeng et al. (2025) and Wang et al. (2023) also cautioned that technology-moderated learning environments can exacerbate inequities when linguistic challenges are present, particularly for students without adequate scaffolding. TEOL offers a variety of activities such as discussion boards, live chats, breakout rooms, and collaborative apps. It could enhance a deeper engagement among students and with the lecturers and increase the number of chances for communication and information exchange. Via this platform, students can participate in socially constructed learning which supports the notion that communication is a key factor in determining academic performance in technologically advanced environments.

Moreover, the negative moderation observed for comprehension and technical language suggests that while digital tools offer opportunities, they can also increase cognitive load. Waymouth and Hinchman (2025) and Hossein et al. (2024) argued that poorly designed digital resources may reduce clarity and accessibility, particularly for learners facing language barriers. This aligns with Balozerova (2021) and Ramiller and Wagner (2011), who highlighted the paradox of technology: while it can democratize access, it can also reinforce barriers when not attuned to learners' linguistic needs.This indicates the need for instructional design that integrates scaffolding, language support, and adaptive features

to minimize such cognitive overload. Taken together, these findings reinforce the view that communication competence, supported by thoughtfully designed TEOL features, is a critical driver of academic success. As Choi-Lundberg (2023) and Bello & Agyeman (2023) noted, pedagogical technologies should be leveraged not merely as delivery systems but as active enablers of interaction, scaffolding, and linguistic inclusivity. Future research should therefore explore how TEOL platforms can be optimized to balance interactivity with accessibility, ensuring that linguistic challenges do not undermine student outcomes.

6. Conclusion and Implications

This study highlights the complex ways in which language-related challenges shape student performance in technology-enhanced online learning environments. While comprehension and technical language contribute meaningfully to academic achievement, their influence appears insignificant when moderated by digital tools as compared to communication challenges.

6.1 Limitations of the Study

Although the study provides meaningful insights into the influence of language-related challenges on student performance within technology-enhanced online learning (TEOL) environments, several limitations should be acknowledged. First, the data relied heavily on students' self-reported perceptions of their comprehension, technical language use, and communication skills. While self-assessments offer valuable perspectives on learners' experiences, they are inherently subjective and may not always align with actual academic performance. Factors such as social desirability bias, overconfidence, or underestimation of abilities could have influenced responses. Future work incorporating objective performance measures—such as grades, test scores, or interaction analytics—would help validate and complement the self-reported data. Second, the study examined TEOL features in a general sense, grouping them as a single construct rather than differentiating between specific modes such as synchronous platforms (e.g., live lectures), asynchronous tools (e.g., discussion boards, recorded videos), or adaptive technologies (e.g., AI-based feedback systems). This broad approach was useful for identifying overall trends but may have obscured the unique ways that different technological formats shape the relationship between language challenges and learning outcomes. It is possible that synchronous tools enhance communication but burden comprehension, while adaptive technologies might better scaffold technical language learning. Without disaggregating these categories, nuanced insights into feature-specific effects remain unexplored. By recognizing these limitations, future research is able to provide a deeper and more accurate understanding of how language challenges intersect with digital learning tools.

6.2 Suggestions for Future Research

The present findings highlight several important avenues that future scholarship could pursue to deepen understanding of language-related challenges within technology-enhanced learning contexts. Future research should consider adopting longitudinal research designs. A cross-sectional approach, while useful in identifying associations, may not fully capture how the influence of comprehension, technical language, and communication evolves as students' progress through different stages of learning. Longitudinal studies would allow researchers to trace changes over time, providing richer insights into whether linguistic barriers persist, diminish, or intensify as learners gain familiarity with both disciplinary content and the digital learning environment. Such designs could also reveal whether repeated exposure to TEOL features strengthens communication competence or, conversely, compounds cognitive load for students facing persistent comprehension challenges. In addition to that, there is scope to integrate mixed-method approaches, combining large-scale quantitative analyses with in-depth qualitative data such as learner reflections, classroom observations, or discourse analysis. Such triangulation would provide a more holistic picture of not only how language barriers affect performance but also how students navigate and adapt to them in real time. By pursuing these directions, future research can move beyond documenting relationships toward designing evidence-based strategies that leverage technology as an enabler rather than an obstacle, ultimately promoting more equitable and linguistically inclusive learning environments.

Acknowledgment

We wholeheartedly acknowledge all the respondents for spending their valuable time on filling out our questionnaire. We also acknowledge the anonymous referee for providing valuable comments.

Ethics Declaration

Ethical considerations were prioritized throughout the research process to ensure the protection of participants' rights and privacy. For this study, there was voluntary participation from the respondents where they are free to participate or withdraw at any time without any consequences. All respondents provided their consent before completing the questionnaire since they were informed about the goal of the study and how their replies would be utilised. The items in the questionnaire were checked and endorsed by the expert. This is to ensure the questionnaires are valid to be used as research instruments for research collection. This process is to ensure research transparency and uphold the highest standards of academic integrity and research ethics.

Declaration of Competing Interest

In preparing for this study, there was no involvement of financial and personal interest among the group of researchers which could have influenced the work reported for this study. The ultimate goal of this study is to contribute to the holy

of knowledge. This study is intended to investigate the influence of language-related challenges on student performance within technology-enhanced online learning (TEOL) environments.

CRediT Author Contribution Statement

Wan Zarifah Hassan is the corresponding author of this article and is primarily responsible for writing the main chapter of the article, which consists of the Introduction, Literature Review, Methodology, Data Analysis, Findings, as well as preparing the acknowledgements. Moreover, she coordinated the article development to ensure coherence and compliance with publication standards.

Fatin Fazrida Peros Khan contributed extensively in the Literature Review, Research Methodology, Data Analysis, and Discussion parts in the article. In addition, she is also responsible for conducting a thorough review of articles for publication purposes.

Wan Rahmah Hassan played an important role in the development of the Introduction and Literature Review. She focused on contextualizing the research background and problem statement, synthesizing relevant studies, and establishing the theoretical framework underpinning the study objectives.

Suhaila Mukhtar wrote the Discussion and Conclusion sections of the article. She emphasized the discussion of the findings, highlighted both theoretical and practical implications, and articulated the conclusions that demonstrate the significance of the study.

Availability of Data and Materials

The datasets generated and analysed during this study and are available based on request to the corresponding author, (Wan Zarifah Binti Hassan), at zarifah@ucyp.edu.my upon reasonable request. Requests for access will be considered subjected to applicable ethical requirements and data protection obligations.

Generative Artificial Intelligence Disclosure

In regard for this study, AI tools were employed solely for language editing, grammar checking, and translation purposes during the report preparation. All the intellectual content included in the report were originally contributed by the respective authors. AI tools were not used to generate the research data, data analysis, findings and conclusions. The authors take the responsibility for the accuracy, validity, reliability and originality of the study.

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