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Research Article:

Personalising Learning at Scale: A Mixed-Method Study of AI-Generated Bilingual Avatars and Adaptive Feedback

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ABSTRACT

The increasing use of Artificial Intelligence (AI) in education has shown strong potential to transform personalised learning, yet the application of AI tools in flexible, bilingual learning environments remains underexamined. Guided by the Cognitive Load Theory (CLT) and Self-Regulated Learning (SRL) theory, the study examined how students navigated and engaged with an AI learning assistant and the use of AI-generated bilingual avatars, where lecturers provided only English scripts and AI, via Synthesia.io, automated the delivery of lecture content in students' preferred language (English or Chinese). Additionally, Noodle Factory, an AI-powered personalised learning platform was used to personalise weekly quizzes by generating AI-based feedback in students' chosen language and creating custom learning pathways responsive to individual performance. This exploratory mixed-method study was conducted over five academic weeks, involving 195 Bachelor of Education student teachers from a private university in Malaysia. Quantitative data were collected on AI-generated video view frequency, quiz participation in Noodle Factory, and engagement frequency with the AI learning assistant. Qualitative data were obtained from interviews with eight purposively selected students. The study found that students strategically engaged with bilingual AI video lectures and the AI learning assistant in ways that supported comprehension and self-regulated learning. Quantitative data showed increased quiz attempts during weeks when bilingual videos were made available, and language usage patterns indicated a preference for English, with selective reliance on Chinese for clarification. Qualitative findings revealed that bilingual access enhanced understanding, enabled flexible learning, and supported academic preparation. The AI learning assistant was used primarily for revision and feedback, although some students noted technical limitations and translation issues. These findings suggest that AI-driven bilingual tools, when aligned with students' cognitive and linguistic needs, can enhance engagement and autonomy in self-paced learning environments. These findings have practical implications for institutions seeking to support bilingual and international student populations.

Keywords: Self-regulated learning, bilingual learning environment, mixed-method, AI avatars

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INTRODUCTION

The integration of Artificial Intelligence (AI) into higher education is reshaping how learners interact with instructional content, feedback, and assessment. AI-powered platforms, particularly those offering personalised and adaptive learning pathways, have demonstrated considerable potential in fostering learner autonomy and engagement. Within digitally mediated and flexible learning environments, the availability of content and support in multiple languages is increasingly recognised as a critical enabler of inclusive education. For students who are not from English-speaking backgrounds, language accessibility plays a central role in shaping their capacity to engage meaningfully with course material, especially in self-directed learning settings.

Globally, higher education institutions are increasingly exploring AI-supported instructional tools to address the challenge of providing personalised learning experiences to large and diverse student populations. The rapid expansion of digital learning environments and hybrid delivery models has intensified the need for scalable systems that can support students with varying linguistic backgrounds, levels of academic preparedness, and learning preferences. In this context, AI-driven instructional technologies have emerged as a promising approach to augment teaching capacity while maintaining accessibility and learner engagement.

In multilingual societies such as Malaysia, where English is the medium of instruction in many higher education institutions, students from non-English-speaking backgrounds often encounter challenges that impede participation and academic confidence. These challenges are further amplified in hybrid-flexible (HyFlex) and asynchronous learning formats, where students are expected to self-regulate their learning with reduced real-time instructional interaction.

Parallel to these developments is the growing use of AI to deliver bilingual or multilingual content, particularly in contexts where students possess varying levels of proficiency in the medium of instruction. AI-generated bilingual lectures delivered in English and Chinese hold the promise of making learning content more accessible and inclusive (Liu et al., 2024; Mayer, 2017). By potentially reducing cognitive load and increasing comprehensibility, such tools may improve learner engagement and performance (Sweller, 2010). However, there is insufficient empirical understanding of how these bilingual AI video lectures are actually used by students and whether their availability translates to greater engagement with course materials or assessments such as quizzes.

Moreover, AI learning assistants like Noodle Factory are gaining popularity for their ability to offer real-time support, provide feedback, and simulate interactive learning. While research exists on the design and potential benefits of such tools (Smutny & Schreiberova, 2020), several gaps remain in the existing literature. First, empirical studies examining how students actually use AI-generated bilingual lecture materials in authentic higher education settings remain limited. Second, while AI learning assistants and intelligent tutoring systems have been widely discussed conceptually, fewer studies

have examined how students interact with these tools in self-paced or HyFlex learning environments over time. Finally, limited research has explored how bilingual AI-generated instructional materials and AI-supported feedback systems operate together within the same instructional ecosystem. Addressing these gaps is critical for understanding how AI tools can be effectively integrated to support both cognitive processing and self-regulated learning in higher education contexts.

Accordingly, this study is guided by the following research questions:

1. What are the usage patterns in the availability of bilingual AI avatar lectures and in students' frequency of quiz attempts?
2. How does the availability of bilingual (English/Chinese) AI avatar lectures affect students' engagement with the course content in a self-paced learning environment?
3. How do students engage with the AI learning assistant (Noodle Factory) in a self-paced learning environment?

By examining both learning analytics data and students' experiential perspectives, this study contributes empirical evidence on how bilingual AI-generated instructional materials and AI-supported feedback systems interact to influence engagement and self-regulated learning in technology-mediated higher education environments.

LITERATURE REVIEW

This section discusses the theoretical foundation and existing literature in relation to the framing of this study. Cognitive Load Theory (CLT) and Self-Regulated Learning (SRL) Theory serve as the theoretical lens to provide insights into how tertiary level students regulate their cognitive capacity in an autonomous AI learning context. The literature primarily focuses on the adoption of AI tools in self-regulated higher education and the roles of bilingual instructions in influencing students' cognitive engagement in an AI-supported environment.

Theoretical Framework

This study is guided by two interrelated theoretical perspectives: CLT and SRL theory. Together, these perspectives help explain how students engage with bilingual AI video lectures and AI learning assistants in self-paced learning environments.

CLT posits that human working memory has limited capacity for processing information (Sweller, 1988). Effective instructional design must manage the mental effort required during learning by reducing extraneous cognitive load and enhancing germane cognitive load (Sweller, 1988). CLT distinguishes between intrinsic cognitive load and extraneous cognitive load. Intrinsic cognitive load arises from the inherent complexity of the learning content, while extraneous cognitive load results from poorly designed instructional content

(Sweller, 1988). In the context of bilingual AI video lectures, language competencies may impact these types of cognitive loads. CLT provides a lens to understand how language accessibility—via English/Chinese delivery—may reduce extraneous load, allowing learners to focus on comprehension and content integration (Mayer, 2017). Mentally shifting between languages may lead to excessively high cognitive load among learners (Nawal, 2018). When learning content is designed using learners' preferred languages, they invest less cognitive effort to translate the information. This lowers extraneous cognitive load, and thus, learners can spend more time understanding complex learning content. This potentially improves content retention and engagement by aligning instructional materials with their cognitive processing capacity. Therefore, bilingual AI videos may be more effective in supporting learners' cognitive processing when their language choices are aligned with learners' preferred languages.

SRL Theory describes how learners actively control their learning processes through planning, monitoring, and evaluating strategies (Zimmerman, 2001). Highly self-regulated learners tend to take more initiative to acquire knowledge and skills (Zimmerman, 2001). In self-paced learning environments mediated by AI, students must navigate content autonomously, make decisions about when and how to engage with materials, and monitor their own understanding. Self-regulated learners take advantage of self-paced learning opportunities to make their own learning decisions and strongly value convenience, student agency, and time flexibility in learning (Athens, 2023). AI can provide instant feedback that helps learners identify their learning gaps; provide explanations that clarify students' doubts on the spot; and step-by-step hints that guide students to the completion of tasks. These features strengthen self-regulated learning.

Integrating CLT and SRL allows for a nuanced examination of learner behaviour in AI-supported, self-paced learning environments, particularly where language and technological mediation are involved. CLT captures the cognitive accessibility of AI-generated bilingual materials, and yet, this approach does not guarantee meaningful learning if students do not take proactive actions in managing their own learning. SRL complements CLT by explaining how learners actively regulate their learning behaviours with the support of AI tools. Translated into our study, these theories account for both the cognitive conditions that make learning possible by AI bilingual videos and the learner-driven processes that sustain engagement through an AI learning assistant.

AI Integration in Self-Paced Learning in Education

Recent advances in educational technology have accelerated the adoption of AI to support flexible and personalised learning in higher education. AI tools ranging from automated content generation to intelligent tutoring systems have become particularly instrumental in self-paced and HyFlex learning environments, where students can choose between in-person, synchronous online, or asynchronous participation (Mahrishi et al., 2025). The systematic literature review by Fernando et al. (2025) summarises 15 features of AI that support students' self-paced learning. For instance, AI tools support the student's autonomy,

allowing individuals to control the pace, sequence, and modality of their learning journey. AI-graded assessment offers learners greater autonomy and flexibility by enabling real-time adaptation, just-in-time feedback, and personalised learning pathways. Students can practice their speaking skills with AI agents in a safe and low-risk environment.

However, a key tension emerges between the promise of autonomy and students' readiness for self-directed learning. While studies showed that AI-supported learning motivates students to be independent, not all learners possess the metacognitive and self-regulatory skills required to benefit from such flexibility (Lim, 2024; Saleh, 2025). Lim (2024) reported that Cambodian English learners responded positively to AI chatbots. AI chatbots were particularly helpful in improving vocabulary, writing and reading skills. 90% were confident in using AI tools for autonomous learning. In contrast, Saleh (2025) found that one-third of the Lebanese university students were unkeen to explore content outside of their course using AI tools. Only one-fifth of them felt motivated and confident with their independent learning skills. The findings imply that factors such as education level, subject and design of AI-integrated platforms might affect the effectiveness of AI use.

Within HyFlex environments, AI facilitates differentiated instruction through analytics and recommendation engines, guiding students to revisit concepts, attempt quizzes multiple times, or engage with supplementary materials. This paradigm also shifts the instructor's role from content deliverer to learning facilitator, utilising AI to mediate interactions and feedback loops. While AI affords self-paced learning, its effectiveness is contingent upon consistent student participation and self-regulation (Athens, 2023). Research shows that while some learners thrive in flexible environments, others struggle with motivation and time management (Athens, 2023; Martin & Bolliger, 2018).

Despite growing interest, several research gaps remain. Few studies offer detailed empirical insights into how students engage with AI tools over time, especially in terms of usage patterns such as video access frequency, quiz attempts, and interaction with AI learning assistants. Second, existing studies tend to rely heavily on self-reported perceptions (Athens, 2023; Martin & Bolliger, 2018), with fewer investigations triangulating these perceptions with learning analytics data from the AI platforms. Addressing these gaps would contribute to an evidence-based understanding of how AI can support diverse learners in self-paced and HyFlex contexts.

Bilingual Instruction and AI Agent in Learning

The use of bilingual instructional content in digital learning environments has gained attention as a strategy to improve comprehension and engagement among linguistically diverse students. In AI-mediated learning, bilingual lectures generated via speech synthesis and machine translation present new opportunities for accessibility, particularly in regions where English proficiency varies. Bilingual videos have been found to facilitate vocabulary acquisition, enhance cognitive skills, improve reading and listening comprehension and encourage learner engagement (Bennett et al., 2023; Feng & Wang, 2023; Ma, 2024;

Teng, 2025). For instance, Teng (2025) found that bilingual captioned videos improve students' ability to recognise the meanings of multiword expressions. Bilingual captions stimulated students to simultaneously process auditory information and written text. This helped students interpret meanings from the text. Similarly, the comparative study by Feng and Wang (2023) showed that students exposed to interactive bilingual reading with audiovisual support demonstrated higher ability in reading comprehension and pronunciation than their peers in the paper book class. They also became more motivated and independent readers. Feng and Wang (2023) conclude that bilingual videos can nurture positive reading habits among young students. Ma (2024) highlights that bilingual videos allow students to switch between languages when their needs arise, creating a more personalised learning experience.

Nevertheless, key tension lies in the dual role of AI-generated bilingual videos as knowledge deliverers and potential source of cognitive complexity. From the perspective of CLT, bilingual modes aid information retention and reduce the extraneous cognitive load associated with monolingual instruction (Sweller, 2010) when students process information in their preferred or stronger language (Mayer, 2017). A study by Bennett et al. (2023) found that bilingual speakers showed increased speech amounts as well as more frequent verbal interactions with the support from bilingual avatars. Ironically, while bilingual videos reduce language barrier, it may introduce additional information processing demand, particularly when students need to split attention between languages. Besides, the effectiveness of bilingual videos hinges on the quality of translation, synchronisation, and learners' language preferences (Liu et al., 2024).

Besides bilingual videos, AI learning assistants, such as Walter in Noodle Factory, also function as conversational agents. AI assistants can support learners through real-time feedback, prompts, and question-answering systems. These assistants are increasingly adopted in higher education to facilitate formative assessment, self-testing, and learner motivation (Holmes et al., 2021). Bennett et al. (2023) added that conversations with AI Avatar influenced utterance count, turn-taking behaviours and speech sentiment. The dialogic nature of such tools is grounded in socio-constructivist principles, where interaction with the system simulates peer or instructor guidance (Mok & Jain, 2023). Another tension emerges between the potential of AI assistants to foster interaction and the variability in actual usage. Prior studies highlight that while some students actively interact with such tools, others may bypass them if the interface is unintuitive or if they perceive limited value (Smutny & Schreiberova, 2020).

Though AI learning assistants are widely adopted, limited empirical evidence exists on how students engage with them in self-paced learning environments, especially when such tools are embedded within larger instructional ecosystems. In addition, while CLT explains how instructional designs influence cognitive load, SRL focuses on how learners monitor and manage their learning strategies. There is a gap in linking these two theories to discuss AI-mediated learning in higher education. Besides, there is less evidence on how AI bilingual videos and AI learning assistants can synergistically support student learning.

Addressing these gaps provides insights into how AI tools can be jointly used to improve student engagement with course content in a self-paced learning environment.

METHODOLOGY

Research Design

This study adopted an explanatory sequential mixed-methods design, comprising a quantitative phase followed by a qualitative phase, to provide a comprehensive understanding of students' engagement with AI-supported learning tools in a self-paced environment. The quantitative phase was conducted first to establish overall patterns of student engagement using system-generated learning analytics. These data provided an objective overview of how students interacted with the AI-supported course materials, including bilingual AI avatar videos, AI-generated quizzes, and the AI learning assistant. Specifically, the quantitative findings addressed RQ1 by identifying trends in video viewing behaviour, quiz attempts, and language use. This phase was critical in mapping the scope, frequency, and variation of engagement behaviours across the cohort, as well as highlighting notable patterns (e.g., fluctuations in language use and increased quiz attempts during weeks with bilingual video availability) that required further explanation.

Building on these findings, the qualitative phase was designed to explain and contextualise the quantitative results by exploring how and why students engaged with the AI-supported tools in the ways observed. Semi-structured interviews were conducted with purposively selected participants to gain in-depth insights into their learning strategies, language preferences, and experiences when interacting with the bilingual AI videos and AI learning assistant. This phase addressed RQ2 and RQ3, allowing the researchers to unpack the underlying reasons behind the observed quantitative trends, such as students' strategic switching between languages, their reliance on AI tools for revision, and their responses to the affordances and limitations of the technology.

Research Context and Participants

The study was conducted at a private university in Malaysia within the implementation of a HyFlex (hybrid-flexible) learning environment, where students were given the flexibility to engage with course content through multiple modes, including face-to-face sessions, synchronous online classes, and asynchronous self-paced learning. This approach allowed students to determine when, where, and how they accessed learning materials, thereby supporting diverse learning preferences and promoting self-regulated learning.

The intervention spanned a 14-week academic semester, during which a total of 14 lecture topics were delivered. While all topics were part of the course, five selected topics were delivered using AI-generated avatar lectures, while the remaining topics were conducted through conventional instructional approaches within the HyFlex environment. Each

lecture topic was supported by formative assessments, including 14 corresponding quizzes designed to reinforce learning and provide continuous feedback.

A key feature of the intervention was the integration of AI-generated avatar lectures created using Synthesia. For the five selected topics, lecturers prepared instructional scripts in English, which were then transformed into video lectures delivered by AI avatars. These videos were produced in a bilingual format (English and Chinese), allowing students to select their preferred medium of instruction when accessing the content. This design enabled students to switch between languages based on their comprehension needs, thereby supporting both conceptual understanding and language accessibility.

In addition to the AI avatar lectures, students were provided with access to an AI learning assistant via Noodle Factory. The AI learning assistant functioned as an on-demand support tool that was available 24/7, allowing students to ask questions related to the module content and receive immediate responses. It also generated review quizzes and practice questions, enabling students to engage in self-testing and receive adaptive feedback aligned with their performance.

All AI-supported learning materials, including the bilingual avatar videos and the AI learning assistant, were accessible through the university's Learning Management System (LMS). Students were required to log in to the LMS to access these resources, ensuring that engagement data (e.g., video views, quiz attempts, and AI interactions) could be systematically captured through the platform's analytics.

The study involved a total of 195 Bachelor of Education student teachers, of whom more than 70% were from non-English-speaking backgrounds. This demographic context underscored the relevance of providing bilingual instructional support within the HyFlex learning design. While the quantitative phase included all enrolled students, the qualitative phase involved eight purposively selected participants. Two students from each of the four tutorial groups were selected based on their level of engagement with the AI-supported tools, familiarity with the platform, and willingness to participate in the interviews. This purposive sampling enabled an in-depth exploration of diverse usage patterns and learning experiences.

Operational Definitions

Video viewing frequency: The total number of times AI avatar videos were viewed by all student teachers in a given week, including multiple viewings of the same video by the same student.

Quiz attempts: The total number of attempts made by all student teachers on weekly quizzes associated with each topic.

Engagement frequency with the AI learning assistant: The total frequency of interactions between all student teachers and the AI assistant, including prompts entered and responses received.

Data Collection and Data Analysis

Descriptive statistics were used to summarise the quantitative data on video views and quiz attempts, addressing RQ1 by illustrating students' usage patterns of bilingual AI video lectures in the self-paced learning environment. This approach was appopriate because the available data consisted solely of frequency counts, which are most appropriately interpreted through descriptive analysis rather than inferential statistics. RQ2 and RQ3 were explored qualitatively through interviews and observations to capture the nature of students' engagement with course content and the AI learning assistant.

For the quantitative phase, data were extracted from the course learning platform that was available as part of the monitoring of participants' activity throughout the semester. The quantitative data comprised system-generated analytics, including:

1. The frequency of AI avatar videos in English and Chinese that were available on Weeks 6, 7, 9, 10 and 11.
2. The average weekly frequency of AI quiz attempts in Noodle Factory, with an overall comparison between the academic weeks with AI avatar videos and those without.
3. Engagement frequency with the AI learning assistant, in terms of prompts and responses in English and in Chinese.

As the data were generated directly from the built-in analytics tools in the AI learning platforms (Synthesia.io and Noodle Factory), no further statistical analysis was conducted beyond descriptive interpretation of trends and frequencies.

For the qualitative phase, semi-structured interview questions were developed by the researchers and reviewed by an expert in educational technology and qualitative research to establish content validity. A pilot interview involving four students, who were not part of the main study, was conducted to refine the wording and structure of the questions and to ensure intra-rater reliability. The interviews with the eight selected participants were audio-recorded, transcribed verbatim, and the transcripts were returned to the respective participants for member checking to verify accuracy.

Two researchers independently coded the transcripts to develop initial codes. They then compared codes and discussed discrepancies until consensus was reached, ensuring inter-coder reliability and interpretive trustworthiness. The coding process followed Braun and Clarke's (2006) six-step framework. Initial codes were derived directly from participants' quotes, grouped into categories based on conceptual similarity, and iteratively refined into

final themes that captured patterns of engagement relevant to RQ2 and RQ3. Table 1 provides examples of coding and category development, showing the progression from participant quotes to initial codes, categories, and final themes. Specifically, Table 1 shows some examples of the overall coding and category development process, based on RQ2, from participant quotes to initial codes, categories and final themes.

Table 1. Examples of the coding and category development process from raw quotes to final themes (RQ2 sample)

Participant quote	Initial code	Category	Final theme
If there is a Chinese version, I can refer to the parts I don't understand. (ST1)	Switching for understanding	Bilingual support for comprehension	Bilingual access enhances comprehension
We can switch freely between Chinese and English. (ST2)	Language flexibility	Independent pacing	Flexible language fosters autonomy
I can replay it at any time to help me review the difficult points. (ST1)	Repetition for mastery	Asynchronous learning	Videos support repeated, self-paced learning
First use Chinese to understand… then memorise in English. (ST1)	Dual-language strategy	Cognitive bridging	Language as a bridge for academic preparation
Some parts of the translation were not accurate. (ST3)	Translation issues	Linguistic and affective limitation	Limitations in linguistic accuracy and affective engagement

Figure 1 presents a thematic map of the relationships between emerging themes for RQ2 and RQ3. Both Table 1 and Figure 1 are aimed to help illustrate how themes were constructed systematically to address RQ2 and RQ3.

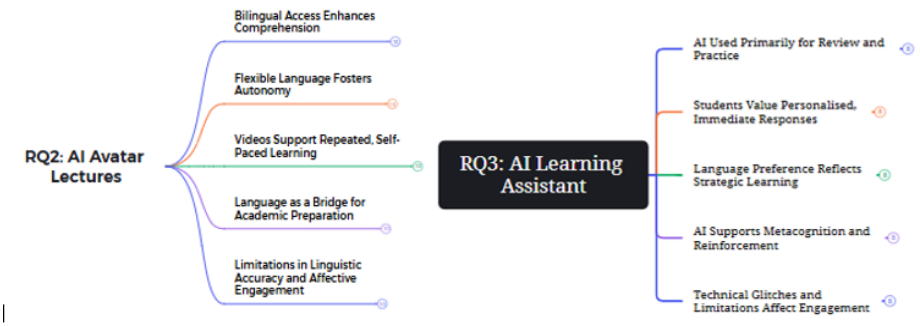

Figure 1. Thematic map showing the themes that emerged from RQ2 and RQ3

To ensure the credibility and trustworthiness of the analysis, member checking was conducted by returning transcripts to participants for verification, and discrepancies in coding were resolved collaboratively by the two coders. Peer debriefing and discussion of coding decisions further enhanced the transparency and rigor of the thematic analysis.

To further enhance the interpretive value of the study, the quantitative and qualitative findings were integrated using a convergent approach. The frequency data from learning analytics, covering video views, quiz attempts, and AI assistant interactions, provided an overview of engagement patterns across the semester (RQ1). These patterns were then interpreted alongside the qualitative themes from interviews and observations (RQ2 and RQ3) to explain the underlying reasons for students' engagement behaviours. For instance, themes related to students' preferences for bilingual content, self-directed learning strategies, and interactions with the AI assistant helped contextualise trends observed in the analytics data. This triangulation of quantitative and qualitative evidence strengthened the credibility of the findings and offered a more comprehensive understanding of student engagement in the self-paced AI-supported learning environment.

FINDINGS

The findings of this study are presented below based on the corresponding research questions.

RQ1: What Are The Usage Patterns in The Availability of Bilingual AI Avatar Lectures and In Students' Frequency of Quiz Attempts?

To investigate students' usage patterns of AI-supported course materials during the HyFlex intervention, quantitative data were analysed from three main indicators:

1. Frequency of bilingual avatar video views.
2. Average weekly quiz attempts in relation to video availability.
3. Language preference in prompts submitted to the AI learning assistant.

The first set of data, as shown in Table 2, illustrates students' viewing frequency of AI avatar videos offered in both English and Chinese languages. While English-language videos generally recorded higher view counts across most weeks, Chinese-language videos showed significant engagement, particularly at the beginning and toward the end of the intervention.

In Week 6, for example, the Chinese-language videos received 80 views, which was more than three times the number of views in English (24 views), suggesting that Chinese-speaking students may have been initially more reliant on content in their preferred language. However, in Week 7, the pattern shifted markedly, with views for English-language videos peaking at 106 compared to only 24 views for Chinese-language videos.

A similar trend continued in Weeks 9 and 10, where English-language videos recorded 26 and 63 views respectively, while Chinese-language videos were viewed only 17 and 15 times. Interestingly, Week 11 saw a narrowing gap, with 47 views for English-language videos and 41 views for Chinese-language videos, indicating a possible resurgence of interest in bilingual access or a more balanced utilisation of both languages toward the conclusion of the intervention.

Table 2. Frequency of AI avatar video views in English and Chinese languages during the intervention weeks

Intervention week	Frequency of views in English language	Frequency of views in Chinese language
6	24	80
7	106	24
9	26	17
10	63	15
11	47	41

In terms of assessment engagement, Figure 2 illustrates the average weekly frequency of quiz attempts in correlation with the availability of AI avatar videos.

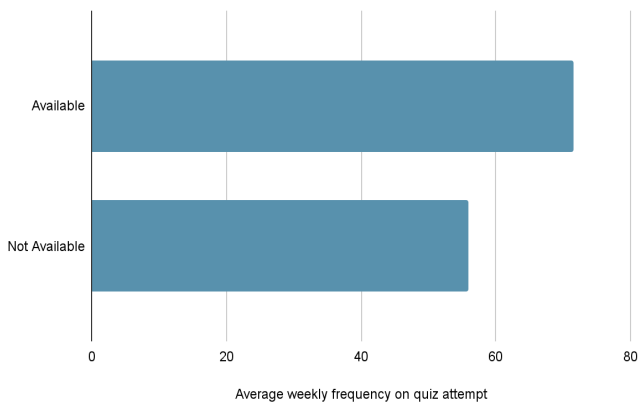

Figure 2. Average weekly frequency of quiz attempt vs. availability of bilingual AI avatar lectures

The data revealed a notable increase in quiz attempts during weeks when bilingual videos were made available (Weeks 6, 7, 9, 10, and 11). When the videos were available, the weekly frequency averaged close to 70. Meanwhile, the average weekly frequency of when the videos were not available was slightly below 60.

Another aspect of student engagement was obtained from how they engage the AI learning tools, as shown in Table 3, which details the frequency of prompts and responses directed to the AI learning assistant, disaggregated by language.

Table 3. Frequency of prompts and responses for each language

In English	In Chinese
256	19

Out of 275 recorded interactions, the vast majority of the prompts (n = 256) were submitted in English, while only 19 prompts were made in Chinese. Nonetheless, the presence of 19 Chinese-language prompts indicates that a segment of students actively engaged with the system in their preferred language.

Bearing in mind the demographics of the participants, where more than 70% of the course students were from non-English-speaking backgrounds, it was notable that the engagement of students with the AI-supported course materials was varied and not monotonous. While students' engagement levels showed high and low frequencies when viewing both the AI avatar videos in English and Chinese, with a higher frequency of quiz attempts when bilingual AI avatar videos were available, there was minimal interaction in Chinese with the AI learning assistant throughout the intervention. From a CLT perspective, this drew attention to the complexity in how students might prefer to use the formal language of instruction (i.e., English) in attempting to discuss and construct schematic representations and conceptual understanding of the content being learned (Sweller, 1988; Mayer, 2017), or show more interest in input-focused engagement (i.e., watching bilingual avatar videos, attempting weekly quizzes when the videos are available) compared to output-focused engagement (i.e., submitting prompts in Chinese to the AI learning assistant). Further understanding of how students may use both languages, or be encouraged to do so, to better manage their cognitive load and subsequently facilitate their learning process and outcomes would be useful.

RQ2: How Does the Availability of Bilingual (English/Chinese) AI Avatar Lectures Affect Students' Engagement with the Course Content in A Self-Paced Learning Environment?

Thematic analysis of students' interview data on the bilingual AI avatar lectures yielded five key themes that shed light on how language accessibility and delivery features influenced their engagement with course content in self-paced learning environments. These themes highlight the cognitive, linguistic, and emotional dimensions of students' interactions with the AI-mediated instruction.

Theme 1: Bilingual access enhances comprehension

This theme encapsulates students' responses that reflect how bilingual access to AI avatar lectures supported their comprehension of course content, especially when English was not their dominant language. Students frequently described switching between English and Chinese versions of the video as a strategy to navigate unfamiliar terminology or complex ideas. For instance, ST1 explained, "There are still English words I don't know or particularly long English sentences … if there is a Chinese version, I can refer to the parts I don't understand." Similarly, ST7 highlighted the usefulness of translation when encountering difficult words: "I can just click the Chinese version, and the words will become Chinese … so I can know what it means." ST2 also shared that, "When I cannot understand English … I can change it to Chinese, and it is convenient for me to check from the dictionary and the translation software". This dynamic and flexible language-switching behaviour enabled students to make sense of abstract or technical content, reducing comprehension barriers during self-paced learning.

Theme 2: Flexible language fosters autonomy

This theme captures students' perception of bilingual flexibility as a tool that enables greater control over their learning process. Rather than relying exclusively on one language, students toggled between English and Chinese depending on their comprehension needs. Many described using English as their default mode, but turning to Chinese as a fallback when facing difficulties. One student (ST4) described this layered approach: "I start with English and if there's any part I do not understand … then I see how that part is explained in Chinese". Another participant (ST2) appreciated the flexibility, stating, "We can switch freely between Chinese and English … and improve knowledge absorption". ST3 added, "If the answer is given in English, I need to translate it separately and understand before I can prompt further. So I might need double time for this." The availability of dual-language content allowed students to tailor the learning experience to their needs, thus fostering independent decision-making and self-regulation.

Theme 3: Videos support repeated, self-paced learning

This theme reflects students' appreciation for the asynchronous and repeatable nature of the bilingual AI video lectures. Students emphasised that the ability to pause, replay, and revisit the videos enhanced their understanding and supported their revision practices. These affordances were seen as essential for managing difficult content, particularly in a self-paced learning environment. "I can replay it at any time to help me review the difficult points", explained ST1. Others shared similar sentiments: "Now can [record] and we can watch it over and over again" (ST5) and "It won't disappear and can't be deleted … I can always refer back to the video" (ST6). The persistent availability of video content allowed students to engage in iterative learning processes that aligned with their individual pacing and needs.

Theme 4: Language as a bridge for academic preparation

This theme highlights students' strategic use of Chinese to build foundational understanding while recognising the eventual need to engage with academic content in English. Students articulated a dual-processing approach: first using Chinese to grasp core ideas and then transitioning into English for formal learning or assessment purposes.

One student (ST1) explained, "We need to first translate what we don't know into Chinese… and then memorise these again in English". ST5 similarly observed, "I think the Chinese maybe makes me have a better understanding, but I use [English] because the literature is in English, so I have to translate in my brain … English is the best I think in the end."

Another student (ST2) reinforced this point: "For the Chinese, we can first use Chinese to understand the concept, and then change the language into English to improve listening skills". These responses indicate an intentional and layered approach to language use, blending comprehension support with academic preparation.

Theme 5: Limitations in linguistic accuracy and affective engagement

This theme captures students' critiques regarding the quality and emotional tone of the bilingual AI video content. While many appreciated the availability of bilingual options, some expressed concerns over translation accuracy and the lack of expressive or human-like delivery. ST3 noted, "Some parts of the translation were not very accurate. When that happens, I need to change to the English version." ST4 also commented that "the Chinese translation is not that accurate … the terms are not standard." ST6 added an important perspective, stating, "It feels like there's no emotion … I just feel the video is there for its own purpose". These sharings point to limitations in both the linguistic fidelity of the AI-generated content and its affective quality, which may have implications for students' engagement and trust in the tool.

Across all the themes explained above, it became clear that the students were using the AI avatar lectures to engage with the course content in an intentional manner. Regardless of the advantages and disadvantages highlighted, the students demonstrated adequate understanding of what actually worked for them, as well as what could be improved. This was a positive sign of self-regulation in using AI, which was crucial for the ongoing debate on the impact that over-reliance may bring to human thinking and cognition (Heersmink, 2024; Yan et al., 2024). The themes demonstrated how students strategically managed their learning process despite the limitations encountered during the intervention.

RQ3: How Do Students Engage with the AI Learning Assistant (Noodle Factory) in a Self-Paced Learning Environment?

Thematic analysis of interview data revealed five key themes that illustrate how students engaged with the AI learning assistant in a self-paced learning environment. These themes reflect students' practical use of the tool, their strategic learning behaviours, and the perceived affordances and limitations of AI-mediated support.

Theme 1: AI used primarily for review and practice

This theme encapsulates how students engaged with the AI learning assistant primarily as a tool for consolidating weekly learning. Rather than using it for exploratory purposes, most students accessed the assistant to revisit lecture content, complete revision exercises, and reinforce their understanding of course topics. ST1 shared, "I often use it to review the knowledge points in class and do some exercises." Others highlighted structured features such as review prompts and exit tickets as particularly useful. For example, ST2 stated, "When I want to review the lecture and write some notes, I always use [the AI learning assistant]. It contains [the] review part and the exit ticket part." ST5 added that the assistant was part of their revision routine: "I will ask the AI revision questions … then I do some exercise and I check and memorise the exercise about the topic". These responses suggest that the assistant functioned as a self-paced revision tool embedded within students' study habits.

Theme 2: Students value personalised, immediate responses

This theme reflects students' appreciation for the AI learning assistant's capacity to provide on-demand, tailored responses that supported their independent learning needs. Rather than waiting for instructor feedback, students used the assistant to check their understanding and clarify difficult content. ST1 noted, "It gives me some simulation questions for me to practice, so I can know which knowledge I have not mastered". ST2 used the assistant to retrieve specific information: "When I ask the AI Walter what are the 10 principles in the assessment … it gives me the specific answer". ST6 emphasised the benefit of receiving multiple explanations: "It gives me a variety of answers … it really helps me to understand the topic better". These excerpts highlight how the immediacy and adaptability of the AI learning assistant contributed to students' ongoing content reinforcement and conceptual clarity.

Theme 3: Language preference reflects strategic learning

This theme captures how students navigated language choices when using the AI learning assistant, often shifting between English and Chinese based on comprehension goals. The use of language was not fixed but part of a broader strategy to manage understanding and academic performance. ST1 shared, "I often communicate with it in English … but when I encounter something I don't understand, I use Chinese". ST5 saw Chinese

as a stepping stone toward mastering English: "If I try AI in Chinese … I will have a better understanding about the concepts, but I will memorise them in English also". ST7 echoed this dual approach: "For understanding, maybe it's Chinese, but to improve my language ability, I prefer to use English". These patterns reflect students' strategic language management in the service of both comprehension and language development.

Theme 4: AI supports metacognition and reinforcement

This theme captures students' recognition of the AI learning assistant as a tool that facilitates reflection and reinforces learning through corrective feedback. Students described how the assistant helped them identify what they had not yet mastered and prompted them to revisit and improve their understanding. ST2 reflected, "Walter can improve our metacognition … I need to know what part I don't understand". ST7 similarly observed, "It supports self-learning … and I can focus on the parts I'm confused about". ST5 emphasised the reinforcement loop provided by the assistant: "If I do some wrong, he will improve that and I can memorise and do it". These reflections point to the AI learning assistant's role in fostering metacognitive awareness and guiding self-directed remediation.

Theme 5: Technical glitches and limitations affect engagement

This theme describes how technical issues and perceived limitations in the AI learning assistant's responses disrupted or reduced student engagement. Several students noted usability problems, including system lags and repetitive outputs. ST7 explained, "Sometimes it will not give the answer I want … it just repeats, 'Hi, how can I help you?'" Similarly, ST8 experienced functional breakdowns: "It was glitchy … I had to reload it again and again … so I stopped using it". Others critiqued the assistant's ability to provide clear or simple explanations, as seen in ST5's comment: "His [Walter's] answer is more complex than the teacher's … I prefer to watch the video again". These experiences suggest that while the tool had potential, inconsistent performance may have undermined trust and deterred sustained use.

The themes above highlighted the nature of the relationship between the student and the AI learning assistant, one that was characterised by metacognitive monitoring. As discussed above for RQ2, this, too, contributes to the demonstration of how students can actually be capable of self-regulating while being dependent on the AI. Moreover, it was not an outright dependency, as evidenced by the ways in which the students were critical and agentive over the role and capabilities of the AI learning assistant (Lodge et al., 2023; Viberg et al., 2018). Nevertheless, the findings suggest that further research is needed to more comprehensively understand the potential of this 'partnership' for learning in the long run, including how it could be more efficiently formed.

Based on the key interpretations of the findings for the three research questions:

1. The variation of trends discovered in student engagement.
2. The demonstration of self-regulation, in relation to the ongoing debate on over-reliance on AI.
3. Further demonstration of self-regulation and metacognitive monitoring in a critical and agentive manner, forming a partnership between the student and the AI learning assistant.

Further discussion is presented in the following section to understand deeper the use and engagement involved.

DISCUSSION

Bilingual AI Avatar Videos as Cognitive and Strategic Scaffolds

The combined quantitative and qualitative findings reveal that bilingual AI avatar videos played a pivotal role in supporting students' engagement with course content, particularly in terms of managing comprehension and pacing. While usage patterns from the platform data showed a general preference for English-language videos, Chinese-language views were notably high in Week 6 and resurged in Week 11. This fluctuating engagement, rather than reflecting a static language preference, points to the role of bilingual delivery as a responsive cognitive scaffold, used strategically based on perceived difficulty or learning phase. Similar to Liu et al. (2024), who found that bilingual AI tools can bridge comprehension gaps among multilingual learners, the present study corroborates that language accessibility enhances inclusivity and comprehension, especially for students navigating complex English-medium instruction. However, describing these tools as "pivotal" risks overstating their role, as it remains unclear whether their contribution reflects deeper learning or increased efficiency in navigating content.

The qualitative findings further support this interpretation. Students consistently reported using the Chinese version of the videos when encountering unfamiliar vocabulary or syntactically complex English explanations. As expressed by ST1, the ability to "refer to the parts I don't understand" in Chinese facilitated smoother comprehension. These practices reflect a learner-driven attempt to regulate intrinsic cognitive load. From the perspective of CLT, these findings suggest that bilingual AI-generated instructional materials may reduce extraneous cognitive load by minimising linguistic processing demands. However, this interpretation warrants further scrutiny. While reduced extraneous load may free working memory resources for schema construction, it may also attenuate opportunities for germane cognitive load, particularly when learners rely on translated input rather than engaging in effortful processing of the target language. In this sense, bilingual AI avatar lectures may function as cognitive scaffolds; however, whether they optimise learning or externalise processing demands remains an open question.

Several students described starting with English and using Chinese only for clarification, indicating a layered strategy that resembles the performance and monitoring phases of SRL (Zimmerman, 2000). For instance, ST4 described this as "a layered approach", moving between languages depending on real-time comprehension. This finding also clarifies why, despite English being the dominant medium, Chinese remained a critical support tool, particularly at moments when students lacked fluency or confidence. The bilingual format functioned as a cognitive release valve, allowing students to recover comprehension before re-engaging in the target language, thereby maintaining flow and motivation (Paas & Sweller, 2012; Maraza-Quispe et al., 2022). The switching between English and Chinese appears deliberate and goal-oriented. However, this interpretation assumes that regulatory processes are internal to the learner. An alternative reading is that regulation is partially distributed to the AI system, raising the possibility that what is observed is not fully self-regulated learning but a form of AI-supported co-regulation.

The asynchronous and replayable nature of the bilingual avatar lectures also contributed to self-regulation. Students consistently noted the usefulness of being able to "watch it over and over again", which allowed them to manage pacing and revisit complex segments at their discretion. This self-paced interaction with video content may support the management of germane cognitive load by enabling distributed practice and reflection (Skulmowski & Xu, 2022). The findings, therefore, extend SRL theory by illustrating how AI-supported instructional tools can provide structural affordances that enable learners to exercise greater control over their cognitive and strategic learning processes in flexible learning environments (Zimmerman, 2001). While replayability supports distributed practice, it may also allow learners to bypass effortful processing by repeatedly accessing explanations rather than constructing understanding independently. This raises questions about whether such affordances promote durable learning or reliance on accessible support. Moreover, students' strategic sequencing of languages, described in Theme 4 as using Chinese to first understand and then English to internalise, points to a form of translanguaging for academic preparation, a sophisticated SRL behaviour that blends cognitive, linguistic, and goal-directed processes. These behaviours are consistent with prior findings on multimedia and SRL (Martin & Bolliger, 2018).

However, the limitations of AI delivery also became evident. Several students questioned the accuracy of the Chinese translations and expressed that the videos lacked emotion or relational presence. These concerns introduce a critical tension. While the cognitive and structural affordances of bilingual AI delivery are evident, the lack of affective engagement may undermine deeper motivational and emotional dimensions of learning (Moreno & Mayer, 2007). From an SRL perspective, the perceived inauthenticity or robotic tone of the videos could impact self-efficacy, especially for students who rely on emotional resonance or teacher immediacy for learning engagement (Brenner, 2022). This limitation echoes findings by Liu et al. (2024), who noted that affectively flat AI narration can weaken emotional connection and learner trust, reinforcing the importance of balancing cognitive efficiency with affective authenticity in AI-mediated instruction. These limitations suggest

that cognitive efficiency alone is insufficient for meaningful learning, highlighting the need to integrate affective and relational dimensions into AI-mediated instruction.

Taken together, these findings suggest that bilingual AI tools do not simply enhance learning but reconfigure how cognitive and linguistic effort is distributed across learners and technological systems.

AI Learning Assistant and Quizzes as Tools for Reinforcement and Metacognitive Regulation

The usage patterns related to AI quizzes and the AI learning assistant suggest that students primarily engaged with these tools as part of a broader revision and reinforcement strategy. Quantitatively, quiz attempts increased during the weeks when bilingual AI videos were available. This association suggests that the avatar lectures provided a level of scaffolding that supported students' readiness to engage with assessments. The presence of prior instructional input, particularly when available in both languages, may have reduced extraneous load, allowing students to approach quizzes with greater cognitive efficiency and confidence (Mayer, 2017). Importantly, increased participation does not necessarily indicate deeper understanding. It may instead reflect increased readiness to attempt tasks due to scaffolded support, raising questions about whether performance gains are sustained without such support.

Qualitative data support this interpretation, especially through students' reflections on how the AI learning assistant (Walter) helped consolidate learning. ST2 and ST5 both described using the assistant for structured review, noting the helpfulness of features such as "exit tickets" and "revision questions". Although these behaviours resemble deliberate self-testing, it remains unclear to what extent these processes are internally generated versus AI-mediated. According to SRL theory, the ability to monitor one's own understanding, identify weak areas, and seek clarification without external prompting is central to learner autonomy (Zimmerman, 2001). The AI learning assistant may be supporting metacognitive awareness, but it may also be substituting for learners' independent evaluative processes.

Students also valued the immediacy and personalisation of the AI learning assistant's responses. When ST1 reported using it to identify knowledge gaps, and ST6 described receiving "a variety of answers", they were engaging in adaptive feedback loops, which are known to support both content mastery and confidence (Athens, 2023). While immediacy and personalisation enhance responsiveness, they may reduce the need for learners to tolerate uncertainty or engage in sustained problem-solving, both of which are associated with deeper learning. The extent to which feedback was linguistically accessible also appears to have shaped its impact. While most interactions with the assistant were in English (n = 256), a minority of students switched to Chinese for clarity. These instances, echoed in the theme of strategic language use, suggest that students selectively manage linguistic load in AI interactions just as they did with the videos. This further suggests that language use is

strategic; however, it also raises the possibility that learners rely on AI to mediate linguistic complexity rather than developing independent proficiency.

Yet, students' experiences with the AI learning assistant were not uniformly positive. Technical glitches, repetitive outputs, and a lack of clarity in responses occasionally disrupted engagement. ST7 and ST8 noted these as reasons for disengagement, with one student choosing to revisit the avatar videos instead. These breakdowns introduced extraneous loads that were both cognitive and motivational. From a design perspective, they suggest that the pedagogical value of AI learning tools is highly dependent on their functional reliability and perceived responsiveness, which, when lacking, can erode trust and undermine self-regulated behaviours. Similar usability challenges were highlighted by Holmes et al. (2021) and Roldán-Álvarez et al. (2016), who warned that technical instability in AI interfaces could diminish perceived learning value and interrupt self-regulatory processes, consistent with the disengagement patterns observed here.

Despite these challenges, many students viewed "Walter" as a tool for reinforcing understanding and promoting reflection. Statements such as "Walter can improve our metacognition" reflect a level of self-awareness in learning. When paired with quiz practice and bilingual video review, the AI learning assistant served not just as an answer generator, but as a scaffold for diagnosing and correcting misunderstandings, thereby closing feedback loops in self-paced, AI-mediated learning environments. This aligns with Viberg et al. (2018) and Lodge et al. (2023), who similarly concluded that AI-based analytics and adaptive systems strengthened learner agency and reflection. While this "partnership" suggests an emerging hybrid learning model, it also raises concerns about dependency, particularly if learners become reliant on AI for feedback, explanation, and validation.

The study contributes to theory by bringing CLT and SRL into dialogue within AI-mediated contexts. However, rather than merely supporting these frameworks, the findings suggest the need to reconceptualise them. Specifically, cognitive load may be redistributed rather than reduced, and self-regulation may increasingly involve interactions with external intelligent systems rather than solely internal processes. These tensions underscore that AI integration does not merely enhance existing learning processes but transforms the conditions under which learning occurs. In the next section, the findings and discussion of this study are extended into potential implications from three aspects: pedagogical, technological, and policy-wise.

IMPLICATIONS OF THE STUDY

The findings of this study carry several implications for the design and implementation of AI-mediated learning environments in higher education contexts.

Pedagogical Implications

First, the strategic use of bilingual AI avatar lectures demonstrated that language accessibility served not only as an inclusion mechanism but also as a cognitive scaffold. As supported by CLT, reducing linguistic complexity allows learners to focus their cognitive resources on comprehension and schema formation. Recent studies have similarly found that providing instruction in a learner's preferred language reduced cognitive barriers and enhanced learning efficiency in digital environments (Liu et al., 2024; Maraza-Quispe et al., 2022). Institutions should therefore consider embedding bilingual instructional options, particularly for diverse cohorts. Features of bilingual videos, such as replayable content, language switching, and flexible pacing, supported students' ability to plan, monitor, and revise their learning strategies. Universities can request the platform developers to include more language-sensitive features. This includes synchronised captions, glossary support and parallel transcripts to create a more seamless AI learning experience.

Secondly, the study reinforces the importance of designing AI tools that promote learner autonomy and self-regulation. Students in this study exercised control over when and how to engage with content, reflecting the performance and self-monitoring phases of SRL. Recent research underscores that AI-enabled platforms can support self-regulated learning when designed to scaffold metacognition, strategy use, and learner autonomy (Lodge et al., 2023; Viberg et al., 2018). These findings align with broader calls for instructional environments that empower learners through personalised and adaptable systems using effective feedback mechanisms. Feedback should go beyond correcting students' work by providing explanations, examples, and step-by-step instructions to encourage developing deep learning. To receive meaningful feedback, students need to have the knowledge of "how to prompt". Universities can organise AI workshops to educate students on how to ask reflective prompts to generate meaningful feedback.

Thirdly, the AI learning assistant (Walter) was found to facilitate metacognitive reflection and feedback-driven learning, provided that it functioned reliably. Students used the assistant to diagnose gaps in understanding, engage in repeated practice, and access personalised explanations-activities shown to promote deeper learning and self-awareness. Recent literature supports the potential of conversational AI to prompt learners' metacognitive engagement, especially in feedback-rich contexts (Heikkinen et al., 2023; Guan et al., 2025). This points to the issue of scalable personalised learning environments. AI assistants are expected to support a large number of diverse learners simultaneously. While conversational AI agents can provide personalised learning support at scale, Bennett et al. (2023) highlighted that the AI agents interrupted conversations more frequently due to its limited turn-taking prediction capabilities. Lecturers need to be mindful when AI learning assistants give overly complex or repetitive responses, as they interrupt personalised learning flow and lead to frustration.

Technological Implications

The impact of AI-supported learning is dependent on technological reliability and the design of the AI platforms. For instance, the effectiveness of bilingual videos relies heavily on the accuracy of translation, particularly the precision of academic terms. Bilingual videos generated through automated translation must maintain linguistic accuracy and synchronisation with visual explanations to prevent misunderstandings. For instance, heteronyms are words spelt identically but pronounced differently with distinct meanings. The automated translation may not be able to distinguish the use of heteronyms in different contexts and languages, leading to additional extraneous cognitive load. This highlights the need for high functional reliability and linguistic sensitivity in AI interfaces. As highlighted by Holmes et al. (2021), if AI tools are poorly calibrated to learners' needs, they may increase cognitive burden and discourage sustained use. In addition, the quality of translations and emotional tone of delivery must also be addressed. Inaccurate or affectively neutral AI content can reduce engagement (Liu et al., 2024; Mayer et al., 2020).

From the design of AI systems perspective, the study provides evidence that effective AI-supported learning depends on alignment between design features and established learning theories. By integrating CLT and SRL as analytical lenses, the study shows that the benefits of AI-mediated tools are realised when cognitive load is optimally managed, and learners are supported to self-direct their engagement. This has particular relevance in HyFlex models, where learners navigate content across multiple modalities and are expected to make autonomous decisions within complex digital ecosystems (Beatty et al., 2022).

Despite these advantages, AI platforms also have a few limitations. It may lack the element of "human touch", including lecturers' sensitivity to diverse students' needs and emotional intelligence (Shao et al., 2024; Singh et al., 2024). AI systems primarily operate through algorithmic processing and pattern recognition, which limit their capacity to understand users' feelings, facial expressions, social cues, and emotions. Emotional intelligence, such as empathy and social awareness, are drivers for strong teacher-student relationships and supportive learning (Singh et al., 2024). Without this layer of genuine care and trust, meaningful learning may not take place. Educators are more competent in addressing complex students' learning issues, while AI tools are effective for conventional and structured tasks (Shao et al., 2024).

Policy Implications

Malaysia Digital Economy Blueprint aims to transform Malaysia into a digitally driven economy and encourage the use of technology and data in teaching and learning (Economic Planning Unit, 2021). In addition, the National Artificial Intelligence Roadmap (2021–2025) (Ministry of Science, Technology and Innovation Malaysia, 2021) promotes embedding AI into curricula and strengthening institutional capacity for technology-driven education. It is recommended that universities institutionalise AI-supported teaching tools to create personalised learning experiences for students. Equally important is the emphasis

on the use of AI as a complementary tool for lecturers and students. For example, lecturers should moderate AI-graded assessments, particularly the ones with rubric-based, open-ended questions. Evaluative judgement from lecturers is crucial to ensure the reliability of the assessment. Similarly, students should not misuse responses provided by AI learning assistants. Policies should highlight the ethical use of AI in learning.

Notably, the digital divide is still a challenge in higher education in the AI era. The digital divide is manifested through unequal accessibility to infrastructure, digital literacy and differences in educational background (Chen & Xu, 2024). Thus, policies should prioritise equitable digital access, addressing the digital divide between university students from high and low-socio-economic status families.

CONCLUSION

This study examined how bilingual AI avatar lectures and AI learning assistants were used and experienced by students in a HyFlex, self-paced learning in the higher education context. Grounded in CLT and SRL Theory, the findings illustrate how language accessibility, autonomous pacing, and interactive feedback shaped learners' engagement with AI-mediated instruction. Quantitative usage patterns revealed that while English remained the dominant medium, Chinese-language options were actively used by students, particularly at key phases of the intervention. Qualitative insights further illuminated how students strategically toggled between languages to enhance comprehension, regulate their learning, and manage cognitive demands. Importantly, the AI learning assistant supported personalised practice and metacognitive reflection, though its impact was limited by technical inconsistencies and the occasional lack of linguistic or emotional nuance in its responses. These findings suggest that well-designed AI tools can scaffold both content understanding and self-regulation, particularly when they offer bilingual support and function reliably.

However, the study is not without limitations. First, the generalisability of findings may be limited by the single-institution context and the relatively short intervention period. Second, usage data from the AI platform may not fully capture students' informal or offline learning behaviours. Future research should consider longitudinal designs and cross-institutional comparisons to deepen understanding of how AI tools mediate learning over time and across diverse contexts.

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REFERENCES

Athens, W. (2023). Self-regulation, motivation, and outcomes in HyFlex classrooms. *Educational Technology Research and Development, 71*, 1765–1783. https://doi.org/10.1007/s11423-023-10243-y

Beatty, B. J., Gehringer, E. F., & Rogers, K. R. (2022). *Hybrid-flexible course design: Implementing student-directed hybrid classes* (2nd ed.). EdTech Books.

Bennett, C. C., Kim, S. Y., Weiss, B., Bae, Y-H., Yoon, J. H., Chase, Y., Yoon, E., Ryu, U., Cho, H., & Shin, Y. (2023). Cognitive shifts in bilingual speakers affect speech interactions with artificial agents. *International Journal of Human-Computer Interaction, 40*(22), 7100–7111. https://doi.org/10.1080/10447318.2023.2261728

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brenner, C. A. (2022). Self-regulated learning, self-determination theory and teacher candidates' development of competency-based teaching practices. *Smart Learning Environments, 9*(3), 3. https://doi.org/10.1186/s40561-021-00184-5

Chen, J., & Xu, Z. (2024). The impact of the digital divide on labor mobility and sustainable development in the digital economy. *Sustainability, 16*, 9944. https://doi.org/10.3390/su16229944

Economic Planning Unit. (2021). *Malaysia Digital Economy Blueprint.* Economic Planning Unit.

Feng, Y., & Wang, X. (2023). A comparative study on the development of Chinese and English abilities of Chinese primary school students through two bilingual reading modes: Human-AI robot interaction and paper books. *Frontiers in Psychology, 14*, 1200675. https://doi.org/10.3389/fpsyg.2023.1200675

Fernando, E., Hassan, R., Murad, D. F., & Al-Mekhlafi, Z. G. (2025). Exploring the artificial intelligence era in influencing self-paced learning: Systematic and bibliometric review of literature. *Educational Process: International Journal, 18*, e2025429. https://doi.org/10.22521/edupij.2025.18.429

Guan, R., Raković, M., Chen, G., & Dragan, G. (2025). How educational chatbots support self-regulated learning? A systematic review of the literature. *Education and Information Technologies, 30*, 4493–4518. https://doi.org/10.1007/s10639-024-12881-y

Heersmink, R. (2024). Use of large language models might affect our cognitive skills. *Nature Human Behaviour, 8*, 805–806. https://doi.org/10.1038/s41562-024-01859-y

Heikkinen, S., Saqr, M., & Malmberg, J. (2023). Supporting self-regulated learning with learning analytics interventions: A systematic literature review. *Education and Information Technologies, 28*, 3059–3088. https://doi.org/10.1007/s10639-022-11281-4

Holmes, W., Bialik, M., & Fadel, C. (2021). *Artificial intelligence in education: Promises and implications for teaching and learning.* Center for Curriculum Redesign.

Lim, K. E. (2024). Understanding the perspectives of Cambodian provincial English learners on using AI chatbots to enhance self-paced learning paths. *International Journal of Research Publication and Reviews, 5*(6), 294–300. https://doi.org/10.55248/gengpi.5.0624.1407

Liu, Y., Zhang, H., Jiang, M., Chen, J., & Wang, M. (2024). A systematic review of research on emotional artificial intelligence in English language education. *System, 126*, 103478. https://doi.org/10.1016/j.system.2024.103478

Lodge, J. M., Kennedy, G., & Lockyer, L. (2023). AI and the future of self-regulated learning. *Computers & Education: Artificial Intelligence, 4*, 100129. https://doi.org/10.1016/j.caeai.2023.100129

Mahrishi, M., Abbas, A., Siddiqui, M. K., & Aladhadh, S. (2025). The genesis and prevalence of the HyFlex model: A systematic review and bibliometric analysis. *International Journal of Educational Research Open, 8*, 100410. https://doi.org/10.1016/j.ijedro.2024.100410

Maraza-Quispe, B., Alejandro-Oviedo, O. M., Fernandez-Gambarini, W. C., Cuadros-Paz, L. E., Choquehuanca-Quispe, W., & Rodriguez-Zayra, E. (2022). Analysis of the cognitive load produced by the use of subtitles in multimedia educational material and its relationship with learning. *International Journal of Information and Education Technology, 12*(8), 732–740. https://doi.org/10.18178/ijiet.2022.12.8.1678

Martin, F., & Bolliger, D. U. (2018). Engagement matters: Student perceptions on the importance of engagement strategies in the online learning environment. *Online Learning, 22*(1), 205–222. https://doi.org/10.24059/olj.v22i1.1092

Mayer, R. E. (2017). *Multimedia learning* (3rd ed.). Cambridge University Press.

Mayer, R. E., Fiorella, L., & Stull, A. (2020). Five ways to increase the effectiveness of instructional video. *Educational Technology Research and Development, 68*, 837–852. https://doi.org/10.1007/s11423-020-09749-6

Ministry of Science, Technology and Innovation Malaysia. (2021). *Malaysia National Artificial Intelligence Roadmap 2021–2025.* Ministry of Science, Technology and Innovation Malaysia.

Mok, S. J., & Jain, J. (2023). Malaysian in-service Science teachers' conception of Nature of Science (NOS). In M. Koc, O. T. Ozturk, & M. L. Ciddi (Eds.), *Proceedings of ICRES 2023- International Conference on Research in Education and Science* (pp. 1049–1062), Cappadocia, Turkiye, ISTES Organization.

Moreno, R., & Mayer, R. (2007). Interactive multimodal learning environments. *Educational Psychology Review, 19*, 309–326. https://doi.org/10.1007/s10648-007-9047-2

Nawal, F. A. (2018). Cognitive load theory in the context of second language academic writing. *Higher Education Pedagogies, 3*(1), 385–402. https://doi.org/10.1080/23752696.2018.1513812

Paas, F., & Sweller, J. (2012). An evolutionary upgrade of cognitive load theory: Using the human motor system and collaboration to support the learning of complex cognitive tasks. *Educational Psychology Review, 24*(1), 27–45. https://doi.org/10.1007/s10648-011-9179-2

Roldán-Álvarez, D., Martin, E., García-Herranz, M., & Haya, P. (2016). Mind the gap: Impact on learnability of user interface design of authoring tools for teachers. *International Journal of Human-Computer Studies, 94*, 18–34. https://doi.org/10.1016/j.ijhcs.2016.04.011

Saleh, E. H. (2025). Empowering learners: Exploring teaching strategies, AI integration, and motivation tools for fostering autonomous learning in higher education. *East Journal of Human Science, 1*(6), 14–35. https://doi.org/10.63496/ejhs.Vol1.Iss6.182

Shao, A., Lu, Z., Zhong, B., Liu, S. Q, & Lu, W. (2024). Human touch vs. AI tech: Understanding user preferences in the future of education. *Computers in Human Behavior, 164*, 108492. https://doi.org/10.1016/j.chb.2024.108492

Singh, A. P., Saxena, R., & Saxena, S. (2024). The human touch in the age of artificial intelligence: A literature review on the interplay of emotional intelligence and AI. *Asian Journal of Current Research, 9*(4), 36–50. https://doi.org/10.56557/ajocr/2024/v9i48860

Skulmowski, A., & Xu, K. M. (2022). Understanding cognitive load in digital and online learning: A new perspective on extraneous cognitive load. *Educational Psychology Review, 34*(1), 171–196. https://doi.org/10.1007/s10648-021-09624-7

Smutny, P., & Schreiberova, P. (2020). Chatbots for learning: A review of educational chatbots and their impact on student learning. *Education and Information Technologies, 25*, 1–25. https://doi.org/10.1016/j.compedu.2020.103862

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12*, 257–285. https://doi.org/10.1207/s15516709cog1202_4

Sweller, J. (2010). Cognitive load theory: Recent theoretical advances. In J. L. Plass, R. Moreno, & R. Brünken (Eds.), *Cognitive load theory* (pp. 29–47). Cambridge University Press. https://doi.org/10.1017/CBO9780511844744.004

Teng, M. F. (2025). Incidental learning of multiword expressions from bilingual captioned videos for language minority students. *The JALT CALL Journal, 21*(1), 1201–1224. https://doi.org/10.29140/jaltcall.v21n1.1201

Viberg, O., Hatakka, M., Bälter, O., & Mavroudi, A. (2018). The current landscape of learning analytics in higher education. *Computers in Human Behavior, 89*, 98–110. https://doi.org/10.1016/j.chb.2018.07.027

Yan, L., Greiff, S., Teuber, Z., Gašević, D. (2024). Promises and challenges of generative artificial intelligence for human learning. *Natural Human Behaviour, 8*, 1839–1850. https://doi.org/10.1038/s41562-024-02004-5

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13–39). Academic Press. https://doi.org/10.1016/B978-012109890-2/50031-7

Zimmerman, B. J. (2001). Theories of self-regulated learning and academic achievement: An overview and analysis. In B. J. Zimmerman, & D. H. Schunk (Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (2nd ed., pp. 1–37). Lawrence Erlbaum Associates Publishers.