AI-Assisted Learning in EMI: A Case Study of Leveraging TTS and Voice Cloning in a Korean EMI Course

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***Abstract*—As English-Medium Instruction (EMI) becomes increasingly prevalent in non-English-speaking higher education, language-related challenges continue to affect both students and instructors. This study explores how AI-assisted technologies, Text-to-Speech (TTS) and voice cloning, can enhance instructional clarity and learner engagement in a STEM EMI course at a Korean university. Drawing on a mixed-methods design, survey responses from 27 undergraduate students and interview data from the course instructor were analyzed to investigate perceptions of Artificial Intelligence (AI)-generated English voice lectures. Factor analysis identified three key dimensions: EMI-related learning challenges, satisfaction with English delivery, and perceived usefulness of AI narrated videos. Qualitative findings highlighted the affordances of standardized pronunciation, replayability, and multimodal delivery in reducing cognitive load. The study also uncovered pedagogical considerations, including tensions between linguistic accessibility and EMI's instructional goals. The findings suggest that AI voice tools can offer meaningful support in EMI, but require careful integration aligned with institutional goals and ethical guidelines.**

***Keywords*—English-Medium Instruction (EMI), Text-to-Speech (TTS), voice cloning, instructional videos**

I. Introduction

Over the past few decades, South Korea has implemented a range of policies to foster the internationalization of higher education. These effects include the widespread adoption of English-Medium Instruction (EMI), the positioning of English as a Lingua Franca of academic discourse, and the accommodation of a growing number of exchange and international students. However, the implementation of EMI presents a range of challenges, for example in advanced courses that require abstract reasoning and technical terminology Many instructors and students lack sufficient English proficiency to fully benefit from EMI, often resulting in cognitive overload, reduced student engagement, and concerns over instructional clarity. This context highlights the need for tools and strategies that can address linguistic barriers without compromising the academic rigor of EMI courses.

Recent advancements in Artificial Intelligence (AI) assisted technologies have opened new possibilities to address these challenges. In particular, tools such as TTS and voice cloning offer promising support for EMI instruction. These tools can provide standardized English narration, reduce variability in pronunciation and intonation, and allow for multilingual support through translated content. For EMI instructors, especially those who are less confident in their spoken English, the technologies may enhance fluency and clarity, thereby alleviating stress associated with delivering content in a second language.

While theoretical discussions on AI in education are growing, empirical research on its implications in EMI, particularly regarding TTS and voice cloning, remains limited. Most previous studies have broadly discussed on AI integration in higher education, with little focus on how such technologies influence student learning and satisfaction, or how instructors adapt pedagogically when implementing AI in content-heavy EMI contexts [1, 2].

To address this gap, the present case study investigates a Korean university STEM course in which AI-assisted TTS, voice cloning, and machine translation were integrated into instructional videos. Drawing on student surveys and an instructor interview, the study explores both student and instructor perspectives. Specifically, this research seeks to answer the following questions:

1) How did a STEM instructor in a Korean EMI university utilize AI-assisted TTS, voice cloning, and machine translation technologies for instructional videos?
2) How did students perceive the effectiveness of these AI-technologies in supporting their learning experience?

Beyond the immediate context of EMI, this study offers broader insights into the role of AI in creating more inclusive learning environments. By enhancing accessibility for linguistically diverse students, AI technologies can help democratize higher education. As Korean institutions continue to expand EMI offerings to attract international students, the thoughtful integration of AI tools may serve not only to enhance comprehension, but also to uphold equity in multilingual classrooms.

II. Literature Review

A. EMI in South Korean Universities

In South Korea, EMI has been promoted as part of broader efforts to internationalize higher education, especially in large research-oriented universities, and science and engineering programs. The adoption of EMI in STEM disciplines is partly driven by the global status of English as a Lingua Franca, which is necessary for scholars and students to access the latest advancements [1, 2]. According to the Korean Ministry of Education, the number of foreign students enrolled in Korean universities continues to rise, with over 186,000 students reported as of 2023 [3]. To attract and accommodate this growing student population and to enhance institutional prestige, universities increasingly mandate EMI courses, often requiring incoming and junior faculty to teach in English while offering financial incentives for doing so [4, 5].

Macaro *et al.* [2] defines EMI as "the use of the English language to teach academic subjects (other than English itself) in countries or jurisdictions where the first language of the majority of the population is not English." (p. 37). A related concept, Content Language Integrated Learning (CLIL), has also gained attention beyond its European origins. While both EMI and CLIL involve the use of English to deliver academic content, Coyle *et al.* [6] emphasizes CLIL's dual focus on both content and language learning, a feature that distinguishes it from EMI, where the primary focus tends to be on disciplinary or content knowledge, and English language acquisition is expected to emerge as incidental byproducts [3–5]. While EMI is widely regarded as a key internationalization strategy, its implementation in South Korea has presented a number of persistent challenges.

B. Language Issues in EMI

Among the various challenges, linguistic issues remain the most pervasive and widely discussed. One of the most frequently cited concerns is the linguistic burden placed on both instructors and students. Studies have shown that when English is not the first language of either group, it can hinder effective communication and lead to reduced comprehension, particularly in content-heavy disciplines such as engineering and science [7]. In such STEM fields, for example, challenges include not only the use of discipline-specific terminology but also the need to manage dual demands of mastering disciplinary content while navigating a second language [8, 9].

The increased cognitive and linguistic demands in EMI often result in suboptimal learning outcomes and reduced teaching effectiveness. Diminished content comprehension, reduced classroom interaction, and heightened anxiety are related to the English proficiency of both students and instructors. Instructors frequently report students' insufficient English proficiency as a major concern [10, 11–13], a sentiment also supported by students' own self-assessments. Students commonly cite limited vocabulary [14] and poor listening skills [15] as major obstacles to understanding EMI lectures. These challenges are further exacerbated by discipline-specific terminology [16, 17], which often requires additional effort for both decoding and retention. A recent study involving three major engineering universities in South Korea confirmed these concerns, showing that many students perceived that using Korean for complex content would be helpful [15]. In response to such issues, instructors are compelled to adapt curricula, teaching methods, or materials to ensure the delivery of content knowledge.

Instructors' English proficiency has also been mentioned as a source of concern in EMI classrooms [15, 18, 19]. Specifically, Dimova and Kling [20] highlight that elements such as accurate intonation, stress, and vocabulary use play a significant role in students' comprehension. Nonetheless, students generally do not expect native-like proficiency from their content area professors [9, 21]. Rather, intelligibility and clarity of explanation are sufficient in EMI, when instructors demonstrate subject matter expertise [20, 21]. In fact, many students prioritize the content knowledge of instructors over their linguistic accuracy, although some still associate higher levels of English proficiency with more effective instruction. Interestingly, students with lower self-assessed English proficiency tend to encounter greater challenge when taught by a native English-speaking instructor.

The impact of EMI on students' language gains remains inconclusive. While some researchers suggest that struggling students may suffer throughout their program when language support is lacking, the limited empirical evidence available points to mixed results regarding the extent and nature of language gains [2, 5, 22]. Although many studies report positive or at least neutral perceptions of English improvement among students, instructors, and administrators [7], these perceptions are not always supported by measurable improvements. When language development is assessed, findings indicate that not all students reach the desired level of proficiency. Insufficient English skills can instead become a major obstacle to content learning.

Graham *et al.* [7] reported only one of the studies in their review directly measured students' English proficiency. This study, conducted by Yang [23], found that while Taiwanese students in an English Tourism programs showed greater improvement in receptive skills compared to non-EMI students. In a similar vein, Sánchez-Pérez [24, 25] reported that EMI exposure contributed to the acquisition of both general and technical vocabulary among engineering students. Furthermore, Aguilar and Munoz [26] documented measurable improvement in engineering students' listening skills, particularly beginners, further complicating the common assumption about the relationship between EMI and language acquisition.

These findings suggest the importance of further research into students' language-related experiences in EMI, including impact of instructors' proficiency and the role of L1 resources on comprehension. In light of these persistent challenges, emerging technologies such as instructional videos and AI-enhanced supports hold promise for reducing linguistic barriers, expanding access to course content, and supporting students' disciplinary learning.

C. Using Instructional Videos and AI Technologies in EMI

Instructional videos have emerged as valuable pedagogical resources in EMI contexts, offering multimodal support for learners who may struggle with domain-specific content delivered in English. The benefits of using educational videos in higher education have been widely documented, often surpassing those of live lectures [27] and traditional static teaching materials such as pictures [28]. Videos also promote flexibility by enabling students to engage in active learning [29] while reserving class time for interactive activities and discussion.

In EMI, instructional videos provide meaningful support for student learning, grounded by Mayer's cognitive theory of multimedia learning [30]. Segmenting long videos into shorter, topic-specific units and maintaining coherence have been shown to be effective across varying student levels and subject matters [31]. Empirical findings from statistics courses further support the value of videos [32, 33], in contexts where many students experience anxiety around cognitively demanding content. These findings may also be relevant to other fields such as STEM.

Typically, instructional videos are effective for delivering factual, conceptual, or procedural knowledge [34], with growing evidence suggesting they may also support the development of practical skills. For example, Park *et al.* [35] found that Korean agricultural high school students in a video-based learning group outperformed those in a traditional classroom on topics such as civil engineering and agricultural technology. Similarly, Gomez-Tejedor *et al.* [36] reported the effectiveness of the flipped approach in enhancing student performance in physics and electricity lab practices. These studies highlight the potential of video-based instruction in facilitating both practical engagement and conceptual understanding.

Compared to face-to-face lectures, videos further offer unique technical affordances that promote learner autonomy. Beyond dynamic visual representation [37], students can pause, replay, and review content as needed, which allows them to regulate cognitive load and customize their learning pace [31, 38, 39]. This is particularly beneficial when students are cognitively overwhelmed or encounter unfamiliar terms.

Videos with captions can be useful for students learning in a second language, as captions support note-taking and clarifying the spoken content [40–43]. For instance, Lee and Mayer [44] found that captioned videos pairing visuals and narration significantly enhanced accessibility for second language learners. More studies have further supported that subtitles help mitigate the transient nature of spoken input in instructional videos, reducing comprehension difficulty [45–46].

Recent empirical work by Kikuchi [47] sheds further light on the role of AI tools in EMI. Through interviews, Kikuchi found that Japanese university students acknowledged the usefulness of AI tools for functions such as text summarization and vocabulary support. However, both students and instructors expressed concerns regarding academic integrity, insufficient institutional guidance, and a lack of training for implementation. While AI was seen as beneficial for routine academic tasks, it was not yet deeply embedded into instructional practices or curriculum design.

Taken together, these findings suggest that although both instructional videos and AI tools hold promise for enhancing EMI learning experiences, their full potential remains underexploited. Especially in Korean EMI contexts, further empirical investigation is needed to explore how these technologies can be systematically integrated into pedagogical design to support more effective language and content learning.

III. Research Methodology

A. Research Design

This study employed a mixed-methods case study design to explore how a STEM instructor integrated AI tools in an EMI course, and how students perceived their effectiveness. The study used qualitative data (interview with the instructor and open-ended student responses) and quantitative data (Likert-scale survey and comprehension quizzes) to provide a multifaceted understanding of the instructional intervention.

B. Research Setting

This study was conducted in a biotechnology EMI course at J university in South Korea during the spring semester of 2024. The course, offered annually, focuses on the physiology of crops and principles for maintaining crop quality during post-harvest storage.

The course incorporates experimental components that are effectively demonstrated than explained through text alone. These components involve detailed protocols for culturing and analyzing plant specimens, and practical demonstrations of biochemical assays. For example, one of the instructional videos provided step-by-step guidance on conducting the DPPH assay, allows students to repeatedly review the experimental process at their own pace.

Recognizing these benefits of multimedia instruction, the instructor created four AI-enhanced instructional videos using ElevenLabs' (elaborated below) TTS and voice cloning. Two videos covered experimental protocols, and the other two delivered lecture content, including one lecture machine-translated and narrated in Spanish to accommodate international students. All videos were shared through the instructor's YouTube channel and used as part of flipped learning.

The videos were made available in two phases: on March 25th, two short videos (6 to 10 min) covering experimental procedures were released; on May 6th, two longer lecture videos (approximately 30 min each) were uploaded.

C. Voice Cloning, TTS, and Multilingual Support

Voice cloning is an advanced AI technology that generates synthetic speech using audio samples from a specific individual. The goal is to produce speech that is natural and indistinguishable from the original speaker, preserving the same linguistic and paralinguistic features.

At ElevenLabs, the voice cloning process begins with the analysis of user-provided audio samples to extract unique vocal characteristics such as phonemes articulation, accent patterns, and tonal qualities [48]. These features are then modeled using neural networks, enabling the generation of synthetic speech that mimics the speaker's voice, even in languages the speaker has never spoken. Unlike traditional TTS systems that rely on pre-recorded, generic voices, voice cloning allows personalized voice generation. Its ability to evoke familiarity and authenticity is expected to enhance listener engagement. The platform supports speech generation in 32 languages, enabling multilingual narration through integration with machine translation.

In this study, the instructor initially used ElevenLabs to generate English narration using his own cloned voice from a script he wrote. Later in the semester, the narration was once switched to a pre-generated voice on the platform, a male native English speaker voice with a standard Midwestern U.S. accent, commonly encountered by Korean students in English education. The transition aimed to enhance clarity, rhythm, and intonation to facilitate comprehension. Additionally, ElevenLabs' multilingual feature enabled the production of on video narrated in Spanish, improving accessibility for Spanish-speaking students.

D. Participants

The participants in this study included the instructor, referred to as Professor Lee (pseudonym), and 27 undergraduate students (14 females and 13 males) enrolled in a biotechnology course at J University. Among the students,

four were international: three native Spanish speakers and one Mongolian. The majority were biotechnology majors, while five pursuing dual majors in related fields such as food engineering and environmental ecology, indicating familiarity with experimental coursework.

Professor Lee holds a PhD from a U.S. institution and has over a decade of experience in EMI, both in the United States and South Korea. At J University, he teaches courses on horticulture and postharvest crop management, often supplementing instruction with Korean-language materials for certain content. To support diverse learners, he actively integrates educational technologies into his teaching. In this course, he adopted generative AI tools to standardize pronunciation, enhance clarity, and provide multilingual access to complex disciplinary content.

E. Data Collection

1) Instructor interview

An in-depth interview was conducted with Professor Lee after the semester. The interview protocol included questions on motivations adopting AI technologies, challenges during implementation, perceptions of student engagement, and perceived impact on learning.

2) Student survey

At the end of the semester, students completed an 11-item survey via Google Forms. The instrument designed by Professor Lee for pedagogical purposes, consisted of eight Likert-scale items assessing satisfaction, perceived benefits, and familiarity with the voice used in the videos; one yes/no question regarding preferences for native-language content; and three open-ended questions eliciting qualitative feedback. While the survey was not piloted in advance, its alignment with the course context and its instructional goals provided meaningful insights into students' experiences. Ethical considerations, such as informed consent and confidentiality, were addressed.

3) Quiz performance and viewing logs

Students completed short comprehension quizzes (multiple-choice and short-answer) after viewing each video. Quiz scores and YouTube analytics (e.g., view count, watch duration) were used to triangulate student engagement. While flipped-learning format did not guarantee high quiz scores, viewing records indicated that most students watched the videos in advance, demonstrating preparedness for class.

F. Analysis

1) Quantitative analysis

Given the non-normal distribution of the data, confirmed by the Shapiro-Wilk test ($p < 0.05$), non-parametric statistical tests were employed. The Wilcoxon Signed-Rank Test was conducted to test whether student responses significantly deviated from the neutral midpoint (median = 3). Results revealed significant deviations for all survey items ($p < 0.05$), indicating strong participant agreement across variables.

An exploratory factor analysis was conducted to uncover latent dimensions within the survey using principal axis factoring with varimax rotation. The adequacy of the data for factor analysis was supported by the Kaiser-Meyer-Olkin (KMO) measure of 0.65 and a significant Bartlett's Test of Sphericity ($\chi^2 = 183.66$, $p < 0.001$). Internal consistency of the survey items was further assessed using Cronbach's α.

2) Qualitative analysis

Data from students' open-ended responses and the instructor interview were analyzed using thematic analysis [49] to identify recurring patterns and insights. Two authors independently coded the data inductively, allowing themes to emerge. Any discrepancies were resolved through discussion to ensure credibility and consistency in interpretation.

IV. Result

The results are presented in three parts according to the type of data collected. First, descriptive statistics and Wilcoxon Signed-Rank test results are reported for the student survey responses. Second, results from the exploratory factor analysis are introduced, followed by qualitative insights drawn from open-ended student comments and the instructor interview analysis.

Together, these findings address the two research questions. Quantitative and qualitative data from students respond to RQ2, which examines students' perception and experiences with AI-assisted instructional materials in EMI. The instructor interview primarily informs RQ2, exploring how AI tools were implemented in his EMI course and how he evaluated their pedagogical impact.

A. Quantitative Survey Results

Table 1 summarizes the results of the non-parametric Wilcoxon Signed-Rank Test conducted for each survey item, as normality was violated (verified via Shapiro-Wilk test, $p < 0.05$). The null hypothesis ($H_0 : \mu = 3$) was tested against the alternative hypothesis ($H_a : \mu \neq 3$), and all survey items showed significant deviations from the hypothetical median ($p < 0.05$).

Table 1. Descriptive statistics and Wilcoxon Signed-Rank test results for students' Likert-scale responses ($n = 27$)[1]

Questions	mean	median	std	*p*
Q1	3.70	4	1.07	0.004
Q2	3.96	4	1.02	<0.001
Q3	3.59	4	1.25	0.021
Q4	3.56	4	1.16	0.018
Q5	3.48	4	0.85	0.010
Q6	3.70	4	0.78	<0.001
Q7	3.96	4	0.85	<0.001
Q8	3.96	4	0.70	<0.001

Note: [1]A list of questions is available in Appendix A.

Students reported overall satisfaction with the pronunciation, intonation, and speed of both Korean instructors (Q1) and Professor Lee (Q2) at J University. While pronunciation alone was not seen as a barrier (Q3), many still experienced comprehension difficulties in EMI lectures (Q4), suggesting persistent cognitive load due to language processing.

The synthesized voice of Professor Lee was perceived as familiar (Q5), and this familiarity appeared to contribute to greater listening comfort (Q6). Students also rated the convenience of TTS and voice-cloned lectures highly (Q7), and expressed support for incorporating such technologies inti EMI courses more broadly (Q8).

B. Exploratory Factor Analysis

Table 2 summarizes the results of an exploratory factor analysis conducted to uncover latent dimensions underlying

students' survey responses. Using principal axis factoring with varimax rotation, three factors with eigenvalues greater than 1 were extracted, cumulatively accounting for 77.78% of total variance.

Factor 1, EMI learning challenges and technology acceptance included four items that clustered around students' perceived stress in EMI, impact of voice familiarity, and support for AI tools. This factor reflects the extent to which generative AI technologies were perceived as mitigating linguistic stress and enhancing accessibility in EMI.

Factor 2, satisfaction with English delivery, consisted of Q1 and Q2, capturing student satisfaction with both Korean professors' English delivery and AI-generated English voice. The strong factor loadings suggest that pronunciation, rhythm, and clarity, whether from human or AI, were not viewed as major concerns to comprehension when standardized or familiar.

Factor 3, perceived utility of AI tools, comprised Q6, Q7, and again Q8, which cross-loaded. This grouping reflects students' positive perceptions of AI tools in terms of their accessibility, flexibility, and learning support. The cross-loading of Q8 indicates that student support for AI tools was tied both to their overall EMI experiences and the functional advantages of AI integration.

All three factors demonstrated acceptable to high internal consistency, with Cronbach's α values of .89 (Factor 1), .88 (Factor 2) and .74 (Factor 3). The factor structure reveals that students' perceptions were shaped by interrelated aspects of MEI learning and the perceived pedagogical value of generative AI technologies.

Table 2. Results from an exploratory factor analysis of the survey

Factor	Survey Item	Factor loading		
		1	2	3
Factor 1: Learning Experiences with EMI	3. Impact of professors' pronunciation on learning	**0.9260**	0.3493	−0.0531
	4. Stress or difficulty in EMI due to students' English	**0.9147**	0.3472	−0.0942
	5. Familiarity of synthesized voice mimicking Professor Lee	**0.7933**	0.0762	0.2541
	8. Support for TTS and voice cloning in EMI courses	**0.5789**	0.3006	0.5394
Factor 2: Satisfaction with Professors' English	1. Satisfaction with Korean professors' English	0.3068	**0.8381**	0.1764
	2. Satisfaction with synthesized Professor Lee's voice (like a native speaker)	0.2185	**0.8675**	0.0563
Factor 3: Perceived Effectiveness of AI technologies	6. Learning impact of familiarity with synthesized voice	0.1147	0.0828	**0.9046**
	7. Convenience of TTS and voice cloning in EMI lectures	−0.0291	0.0423	**0.6211**
	8. Support for TTS and voice cloning in EMI courses	0.5789	0.3006	**0.5394**

C. Qualitative Insights

However, nuanced opinions on the use of AI-generated voice and multilingual support emerged in students' comments. While many appreciated the clarity and consistency of standardized pronunciation and the flexibility of video-based instruction, others raised concerns regarding the naturalness of synthetic speech and the appropriateness of native-language support in EMI.

1) Clarity and familiarity of synthesized speech

Several students highlighted the clarity and familiarity of the synthesized voice, in contrast to the variability of pronunciation in other EMI lectures at J University. One student said that "*Standardized pronunciation helps reduce confusion and facilitates clearer communication.*" While another noted that "*I could hear standardized pronunciation more clearly, which made it easier to understand and more familiar".*

These comments suggest that the AI-generated voices modeled after the instructor contributed to improved comprehension and reduced cognitive load, echoing the quantitative findings (e.g., Q2, Q7) related to voice clarity and pacing. Furthermore, some students noted its broad pedagogical potential: "*It seems effective in overcoming limitations in pronunciation and delivery, and I would recommend it to other professors as well. I believe that international students, who might find Korean-accented English challenging, would feel more comfortable listening to this voice".*

2) Perceptions of native-language support

Students also expressed diverse views on native-language support through multilingual voice cloning. For instance, one Spanish-speaking student described the availability of Spanish narration as highly beneficial: *"If Korean lectures were taught in Spanish, it would be very convenient because I would be able to take more courses of my major. Sometimes for me it is a bit difficult to understand Korean vocabulary when it comes to scientific terms".*

Conversely, other students expressed reservations about abandoning English in EMI. One student noted, "*I would prefer English as the standard language", and another commented, "Korean professors using TTS in English may be helpful, but switching to native languages like Korean via TTS feels unnecessary*". These contrasting views reflect a tension between enhancing linguistic accessibility and preserving the intended goals of EMI. While some students benefit from having content in their first language, others prefer maintaining English as the academic medium. This suggests that use of multilingual support should be contextually adapted.

3) Convenience and flexibility of video-based learning

In addition to the perceived benefits of synthetic voice and multilingual options, students emphasized the technical affordances of AI-generated instructional videos. One student noted that such tools *"can provide lectures in language that students are good at, or even in their native language,"* while six others appreciated features such as accurate subtitles and the ability to review content on demand.

These findings align with prior research on flipped learning and multimedia instruction, emphasizing how on-demand access, self-paced learning, and multimodal support help students manage the dual challenges of learning content through a second language.

4) Professor Lee's experience of implementing technologies

To explore the instructor's experience with AI-assisted video instruction, a thematic analysis of the interview identified three main themes: (a) motivation for adoption, (b) perceived pedagogical benefits, and (c) implementation challenges and ethical concerns. The themes illuminate the instructor's intentions, instructional adjustments, and reflections on using TTS and voice cloning technology in a content-based EMI course.

a) Motivation for adoption

Professor Lee's initial motivation to adopt generative AI tools stemmed from his long-standing concern with language barriers in EMI, the burden of pronunciation and delivery for non-native English-speaking instructors. Reflecting on own experiences, he recounted:

"The first semester was really tough. ... But the real challenge came after I graduated—when I started teaching. Standing in front of a class, lecturing for hours in English… I found myself worrying more about my accent, intonation, and pronunciation than the actual content of my lectures. As time went on, I got more used to it, and it became less of a concern. But even now, I can't say I feel completely confident about my pronunciation. It's something that still lingers in the back of my mind".

This concern was not limited to his own teaching. He also observed that his students, including international students, struggled with Korean-accented English, in addition to the cognitive load of learning in a second or foreign language. To address these challenges, he turned to AI-generated speech technologies that could deliver clear, consistent English, aiming to reduce misunderstanding. Thus, his goal was not only to improve intelligibility, but also to create a more inclusive learning environment for students from linguistically diverse backgrounds.

b) Perceived pedagogical benefits

Using AI-generated instructional videos has several pedagogical benefits, in enhancing responsiveness to students' learning needs. He noted that interaction data from video playback offered insights into students' comprehension difficulties.

"While making these videos, I actually get a better sense of what students struggle with. For example, by looking at the playback data from previous lectures, I can see which parts students tend to rewatch or spend a lot of time on. When I notice a certain section getting a lot of replays, I take a closer look and realize, "Oh, this must be a tricky part for them." So, for the next video, I will make sure to explain that section more thoroughly, and I will also highlight it in class. It not only makes my lectures more effective, but it also improves student satisfaction".

These insights enabled him to revise future videos more strategically and tailor classroom instruction by reinforcing complex content. He also observed that students who previewed the video content in advance were more engaged during in-class activities. As he remarked, *"Those who previewed the content participated more actively in lab activities"*. This illustrates one of the intended benefits of flipped learning, wherein students come to class with foundational understanding and participate more meaningfully in class activities. The integration of AI tools facilitated a more adaptive and data-informed approach to instruction.

c) Implementation challenges and instructional concerns

Despite these benefits, Professor Lee acknowledged several implementation challenges. One issue was the inconsistent student engagement with flipped learning materials. Although videos were designed as preparatory content, some students delayed viewing them just before class. He recalled, *"I assumed that students would watch the video before class, so one day, I went straight into the experiment. But then I noticed that the students were suddenly scrambling to watch the video at the last minute".*

The experience highlighted the need to establish a shared understanding and mutual commitment to the flipped learning model. Although the videos had the potential to enhance learning, their effectiveness depended on students' willingness to engage with the materials as intended. Professor Lee noted that earlier attempts to check comprehension through quizzes were not successful, reinforcing the importance of explicit agreements with students about their responsibilities in such models.

Additionally, Professor Lee expressed concerns about the accuracy of machine translation, when applied to domain-specific scientific terms used. Although he had not personally encountered a clear mistranslation, he remained cautious about relying solely on automated outputs. He worried that the complexity of terminology could lead to misunderstandings if translations were not carefully verified.

V. Discussion

A. Addressing Linguistic Challenges through AI Tools

This study demonstrates how TTS and voice cloning technologies in instructional videos can mitigate core linguistic challenges in EMI. Consistent with prior research on EMI in non-Anglophone contexts [2], students' limited English proficiency remained a significant barrier to grasping complex academic content in a university course. For students whose first language differs from the medium of instruction, studying STEM subjects through EMI could place additional strain on their cognitive capacities [8].

Student feedback and factor analysis jointly suggest that AI-generated narration can alleviate this cognitive burden by improving the clarity and consistency of spoken English. The first factor (Cronbach's α = .89), which included items related to pronunciation difficulties, language-related stress, and perceived support from AI tools, underscores how students experienced a reduced linguistic load using these technologies. This aligns with Dimova and Kling [20], who noted the pedagogical benefits of standardized synthetic voice, and is also supported by Mayer's cognitive theory of multimedia learning, which highlights the value of dual-channel input and learner-controlled pacing [30, 50].

The availability of instructional videos further supported students by enabling repeated playback, variable speed control [31, 39, 40], precise subtitles [51], and AI-generated summaries [52]. These multimodal affordances proved effective for students with limited English proficiency, reinforcing previous findings on the importance of flexible, learner-centered support in EMI contexts [2, 7, 15, 44].

B. Balancing Accessibility and English Immersion Goals

Although AI narration improved clarity, few students mentioned the quality and naturalness of synthetic speech. Some noted that while it improved access to content, the delivery lacked emotional nuance or a human presence. These mixed responses reflect a tension in using AI voices or AI teachers in instructional videos, which might be related to the instructor's credibility and student engagement [53].

Regarding the question on having access to educational materials in their first languages with the help of AI technologies, students' varying responses also reflected a tension in EMI pedagogy: improving accessibility while maintaining the language immersion intended by EMI policies [14].

This challenge becomes even more apparent when considering multilingual capabilities. Many students in this study welcomed the versions of lectures in their first language; however, both Korean and Spanish-speaking students emphasized that access to L1 content should not undermine opportunities to develop English academic literacy. AI's multilingual capabilities offer opportunities to make EMI courses more inclusive for a broader audience, which supports institutions' global outreach efforts these days. These results suggest the importance of a carefully scaffolded content delivery strategy in EMI, in which AI-generated native-language support functions as a supplementary aide rather than a substitute for English input [54].

C. Instructor Insights and Flipped Learning Implementation

Professor Lee's reflections revealed a nuanced understanding of the pedagogical affordances and limitations of AI tools. As seen in prior research [55], the use of learning analytics informed real-time pedagogical adjustments, particularly when students replayed difficult sections of lecture videos. However, challenges of student engagement emerged, which are critical in the success of flipped learning [56]. Research has shown that successful flipped learning requires students to actively engage with pre-class materials, which directly impacts the quality of in-class activities and learning outcomes [32, 57, 58]. These findings are consistent with Thai et al. [58], who emphasizes that flipped learning requires both learner motivation and the presence of structured accountability mechanisms. When a supportive learning environment is created, it could encourage instructors to sustain their efforts to implement innovative teaching approaches [56].

This suggests that AI-enhanced instructional tools should be embedded within a coherent and explicitly articulated pedagogical design. Without explicit instruction, students may fail to fully utilize the potential of pre-class materials. The integration of automated reminders, embedded quizzes, or LMS-linked checkpoints may enhance student compliance and learning outcomes [59].

D. Ethical and Institutional Considerations for Scaling AI in EMI

While this study presents promising outcomes, it also surfaces ethical and institutional concerns. Voice cloning raises questions about informed consent, data privacy, and the potential commodification of an instructor's voice. The instructor in this study provided informed consent for voice replication; however, broader institutional policies may be required to govern such practices. These include data ownership and usage rights.

From an institutional policy perspective, AI narration offers a potentially scalable solution to staffing shortages and instructor preparedness for EMI, in specialized STEM fields as well. However, universities should critically evaluate the pedagogical trade-offs involved. Faculty development programs should encompass both technical training and pedagogical supports, while offering ethical guidance for responsible technology usage.

In addition, this study also employed machine-translation to generate a Spanish version of one video, as a means to enhance inclusivity for diverse learners. While such multilingual accessibility improves comprehension, it is true that instructors who do not speak the target language are unable to verify the accuracy of translated content. Instructors should be aware that domain-specific errors my persist, despite advancements in machine translation [60, 61]. This raises concerns about content fidelity and academic integrity, requiring institutional guidance that balances the pedagogical benefits of linguistic accessibility with the risks of miscommunication and epistemic inaccuracies.

VI. Limitations and Conclusion

This study is not without limitations. First, it examined a single course with 27 students and one instructor in a Korean university. While the case study approach offered depth, the findings may not be generalizable to broader contexts. Second, the qualitative findings relied on self-reported survey responses and one instructor interview, limiting the scope for triangulation. In addition, because the survey was administered during the course by the instructor, students may have been reluctant to provide critical or negative feedback despite assurances of anonymity. This contextual factor may have led to a limited range of perspectives in the qualitative data, potentially underrepresenting more skeptical or critical views on the use of AI tools. Third, although some quiz and grade data were collected, students' overall low scores made it difficult to evaluate the pedagogical effectiveness of the AI-enhanced videos. Given the optional engagement with pre-class materials, the available data were insufficient to draw robust conclusions about the impact of AI technologies on student learning outcomes.

Future studies should incorporate longitudinal and performance-based data to assess impacts of AI tools on learning outcomes, include larger and more diverse student samples across institutions, and investigate how learners with varying English proficiency respond and interact with AI-generated content. Additionally, the ethical dimensions of AI deployment in education, particularly regarding voice ownership and human-AI interaction dynamics, also merit further investigation.

This study illustrates how AI-driven tools such as TTS and voice cloning can be strategically integrated into EMI contexts to reduce linguistic barriers and enhance accessibility. Students generally perceived these technologies as beneficial in improving comprehension. Moreover, instructor reflections further reveal how AI supports

pedagogical innovation, particularly in flipped learning frameworks.

However, the study also highlights several critical considerations: the need to balance English immersion with linguistic accessibility, address ethical concerns related to AI voice use, and sustain student engagement with AI-enhanced materials. As universities continue to adopt AI technologies, careful alignment with pedagogical goals, ethical standards, and institutional contexts is essential to foster inclusive, effective, and equitable learning environments.

APPENDIX

Q1. How satisfactory was Korean instructors' pronunciation, intonation, and speed in delivering lecture content for your understanding?

(1: very unsatisfied, 5: very satisfied)

Q2. How satisfactory was the pronunciation, intonation, and speed of the English lecture synthesized in Professor Lee's voice to sound like a native speaker in delivering content overall?

(1: very unsatisfied, 5: very satisfied)

Q3. Have you felt that instructors' pronunciation, intonation, etc., in English lectures negatively influence your learning overall at J University?

(1: very negatively affected, 5: not affected at all)

Q4. Have you ever found English lectures stressful or difficult due to your English listening and comprehension abilities (unfamiliar words, listening comprehension)?

(1: many times, 5: never)

Q5. Have you found that lectures cloning Professor Lee's voice were more familiar than other synthesized voices?

(1: very unfamiliar, 5: very familiar)

Q6. Do you think the familiarity of the synthesized voice positively impacts your learning?

(1: very negative, 5: very positive)

Q7. Do you think lectures created through TTS and voice cloning provide convenience to learners in terms of pronunciation, intonation, speed, etc.?

(1: very negative, 5: very positive)

Q8. Do you support the use of English lectures with TTS and voice cloning in undergraduate and graduate courses?

(1: strongly disagree, 5: strongly agree)

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Y.-S.S. was involved in data collection; Y.Y.A. conducted the literature review. Both authors jointly analyzed the data and wrote the manuscript. All authors had approved the final version.

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