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Learner Engagement and Teacher Burden in a Metaverse-Based Korean Language Platform: Implications for AI-Supported Education

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This study qualitatively examines how learner engagement and instructional burden are shaped in a metaverse-based Korean language learning environment, with implications for artificial intelligence (AI)-supported education. A single-case analysis was conducted with an advanced Korean language learner participating in the Metaverse Sejong Institute (MSI). The findings revealed that MSI effectively promoted learner engagement through spatial autonomy and culturally contextualized environments, fostering immersion and sustaining participation. However, the platform's unintuitive interface design and limited system-level interactional support generated an extraneous cognitive load for learners. This burden was subsequently redistributed to instructors, who were required to assume expanded roles as interaction orchestrators and technical mediators, in addition to their core instructional responsibilities. These challenges were particularly pronounced in the absence of AI-based navigation guidance, interactional mediation, and adaptive feedback systems. Based on these findings, the study suggests that in immersive learning environments, AI must be conceptualized not merely as a tool for content delivery or assessment, but as pedagogical infrastructure that mediates interaction, reduces unnecessary cognitive load, and enables sustainable teaching practice. In conclusion, this case underscores the critical need for the systematic integration of AI support in metaverse-based educational design.

Key words: AI in education, metaverse-based learning, learner engagement, teacher workload, Korean language education

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Ⅰ. Introduction

Recently, artificial intelligence (AI) has become a central topic in higher education research, particularly in relation to automation, personalization, and feedback systems. AI-driven tools such as intelligent tutoring systems, adaptive learning platforms, and automated assessments have been widely discussed as mechanisms for improving efficiency and scalability in online education, especially in screen-based and content-centered learning environments(Zawacki-Richter et al., 2019).

As higher education increasingly experiments with immersive and spatial digital environments, such as virtual reality (VR) and metaverse-based platforms, the role of AI requires reconsideration. In these environments, learning extends beyond consuming content on screen to include navigating spaces, interpreting visual cues, coordinating interactions, and managing real-time communication. Such demands introduce new forms of cognitive load and instructional complexity that are not fully addressed by the AI-centered models originally developed for linear screen-based instruction (Makransky & Petersen, 2021).

Language education provides a particularly salient context for examining these issues. Globally, the Korean Wave has reshaped who learned Korean and for what purposes, with a growing number of learners motivated by cultural interest rather than purely academic or occupational goals (Park et al., 2025). In Korea, learner populations have also diversified to include immigrants, international students, and foreign workers, increasing the need for learning environments to be flexible, accessible, and capable of supporting meaningful interactions beyond traditional classrooms.

During the COVID-19 pandemic, higher education institutions rapidly adopted video-conferencing tools to sustain instruction. Although this shift ensured continuity, it largely preserved teacher-centered and text-based pedagogical models, i.e., a phenomenon widely characterized as emergency remote teaching rather than pedagogical transformation (Hodges et al., 2020). By contrast, research on experiential and immersive learning suggests that engagement and retention are enhanced when learners act within a space rather than passively observing content. This pedagogical shift from watching to doing has contributed to a growing interest in immersive platforms as potential environments for language learning.

Against this backdrop, the Metaverse Sejong Institute (MSI) was launched in 2023 as part of Korea's national initiative to expand Korean language education using digital technologies. Designed as a mirror-world environment that recreates familiar cultural and social spaces, MSI aims to integrate language learning, cultural exposure, and real-time interactions within a virtual setting. Although the platform offers promising opportunities for immersion and learner engagement, its operation reveals the tensions between pedagogical intention and system design.

Importantly, discussions on AI in immersive learning environments often assume the presence of intelligent support that facilitates navigation, interaction, and learning. In practice, however, many metaverse-based educational platforms operate with minimal AI integration, leaving tasks such as guiding learners, managing interaction flows, and resolving usability issues for instructors.

This gap raises a critical question for AI-focused higher education research: what happens when immersive learning environments are implemented without the AI-supported scaffolding that their complexity implicitly demands?

This study addresses this question through a qualitative case analysis of an advanced Korean language learner's experience at the MSI. Rather than evaluating specific AI functions, we examine how usability design, affordance cues, and interaction structures shape learner engagement, and how limitations in system-level support redistribute instructional responsibility to teachers. By focusing on a concrete learner experience, our study aims to illuminate the pedagogical and infrastructural challenges that emerge in immersive higher education contexts where AI is absent or underdeveloped.

By situating these findings within broader discussions for AI in higher education, this study suggests that AI must be understood not only as a tool for content delivery or assessment but also as a form of pedagogical infrastructure. In immersive learning environments, AI has the potential to mediate interactions, reduce the extraneous cognitive load, and support sustainable instructional practices. The absence of such support, as revealed in this case, underscores the need for closer collaboration between educators and technology designers in the development of AI-integrated immersive language learning platforms.

Ⅱ. Literature Review and Background

1. AI in Higher Education: From Automation to Situated Support

Research on AI in higher education has largely focused on automation-oriented functions such as grading, content recommendation, and adaptive feedback. More recently, generative AI has been discussed as an instructional support layer that could provide on-demand guidance, extend feedback opportunities, and redistribute routine instructional work that instructors would otherwise perform (Zawacki-Richter et al., 2019). Empirical reports on course-specific AI tutors further suggest that AI-supported learning can improve learning efficiency and outcomes compared with conventional classroom conditions, including active learning baselines (Mollick & Mollick, 2023; Kasneci et al., 2023).

Despite these advances, most of the literature remains grounded in screen-based linear instructional settings. As learning environments become more spatial, interactive, and synchronous, the role of AI shifts from content optimization to situated support embedded within ongoing activities. In immersive environments, AI is no longer merely a recommender system but a potential mediator of navigation, interaction, and sense-making at the point of need.

2. Immersive Learning Environments and the Pedagogy Gap

Immersive virtual environments (IVEs), including virtual reality (VR) and metaverse-based platforms, are often justified by their potential to enable contextualized, interactive, and learner-centered activities. Nevertheless, systematic reviews indicate that research in this area frequently prioritizes technological development over pedagogical design, resulting in a persistent pedagogical gap between immersive affordances and instructional goals (Kestin et al., 2024).

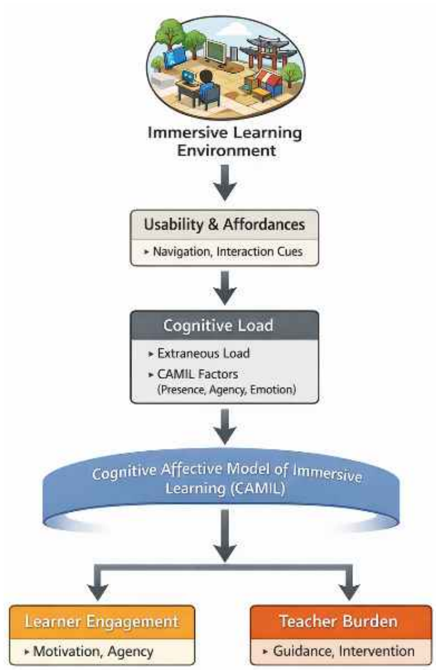
This gap is particularly important in language education. Learning outcomes in IVEs depend not only on exposure or presence but also on how interaction is structured, how tasks are framed, and how learners are guided to participate meaningfully. Without this pedagogical design, immersion risks remaining experiential rather than instructionally productive.

3. Cognitive Load and Usability in Immersive Learning

A central concern in immersive learning research is the cognitive overhead introduced by complex interfaces and rich sensory inputs. The cognitive load theory emphasizes that learning is constrained when working memory resources are consumed by extraneous demands unrelated to the learning task itself(Sweller et al., 2019). In immersive environments, these demands often arise from navigation ambiguities, unclear affordance cues, and inconsistent interaction feedback.

The cognitive affective model of immersive learning (CAMIL) provides a useful framework for understanding this dynamic. According to CAMIL, technological features shape psychological affordances such as presence and agency, which in turn influence affective and cognitive processes, including cognitive load and self-regulation, which ultimately affect learning outcomes (Makransky & Petersen, 2021). Related usability research highlights interactive quality and flow as preconditions for sustained engagement in VR learning environments (Huang et al., 2021). Together, these perspectives suggest that usability is not peripheral but foundational to effective immersive learning.

Figure 1 illustrates the conceptual relationships between immersive environmental features, usability, affordance clarity, cognitive load, learner engagement, and instructional burden.



<Figure 1> Cognitive load, usability, and engagement in immersive learning environments

The figure presents the Cognitive-Affective Model of Immersive Learning (CAMIL), which posits that immersive technologies foster psychological affordances—particularly presence and agency—thereby modulating the affective and cognitive mechanisms underlying learning experiences (Makransky & Petersen, 2021)

Usability and affordance clarity operate as critical mediating conditions: when interaction cues are unclear, extraneous cognitive load increases, diverting attention away from learning activity (Sweller et al., 2019; Huang et al., 2021). In AI-limited immersive environments, this increased cognitive load is not absorbed by the system but is often redistributed to the instructor in the form of additional interactional mediation and breakdown repair, linking learner experience directly to instructional burden.

4. Affordances, Interaction, and Actualization in Language Learning

Immersive environments offer language-learning affordances such as avatar-mediated interaction, contextualized scenarios, and multimodal meaning making. However, affordances become educationally meaningful only when learners perceive and actualize them through activities. In the absence of clear cues or structured interactional support, learners may struggle to move from exploration to purposeful communication.

Evidence from the MSI illustrates both the potential and limitations of immersive language learning. Qualitative research has shown that learners could experience MSI as a socially meaningful space in which embodied interactions and peer presence sustained engagement (Jung, 2025). Simultaneously, technical friction and usability constraints can disrupt participation, underscoring the importance of scaffolding that supports interaction continuity.

5. AI as Pedagogical Infrastructure in Immersive Language Learning

Recent studies suggest that AI can play a critical role in strengthening immersive learning conditions by functioning as an embedded pedagogical infrastructure (Hemminki-Reijonen et al., 2025). Generative AI-powered agents, such as conversational non-player characters (NPCs) and in-situ guidance systems, have been proposed as mechanisms for providing contextualized support, extended practice, and adaptive scaffolding within immersive environments (Hemminki-Reijonen et al., 2025; Huang et al., 2021).

From this perspective, AI is best understood not as a replacement for teaching, but as an augmentation layer that reduces extraneous cognitive load, sustains interaction when human presence is limited, and supports instructional decision-making.

As shown in Table 1, the presence or absence of AI support reshapes the distribution of cognitive, interactional, and instructional work in immersive learning environments. In AI-limited contexts, such as MSI, responsibilities related to navigation, interaction, and cognitive regulation are largely absorbed by learners and instructors rather than being supported at the system level.

<Table 1> Roles of AI as Pedagogical Infrastructure in Immersive Learning Environments

Functional area	AI－limited environment	AI－supported environment
Navigation	Learners must infer spatial structure independently; instructors provide ad hoc verbal guidance	AI－based navigation support offers in－situ directions and visual or linguistic cues, enabling autonomous movement
Affordance recognition	Interactive possibilities are unclear; trial－and－error and instructor explanation are required	AI explicitly signals actionable objects and provides immediate feedback on possible actions
Interaction	Initiation and maintenance of interaction depend heavily on instructor intervention; interaction collapses when peers are absent	AI or NPC conversation partners provide alternative interactional pathways and sustain communicative activity
Cognitive load manage－ment	Interface interpretation imposes extraneous cognitive load on learners and instructors	AI redistributes cognitive demands at the system level, reducing unnecessary extraneous load
Instructio－nal orchestration	Instructors simultaneously act as content experts, interaction managers, and technical mediators	AI handles routine guidance and coordination, allowing instructors to focus on higher－order pedagogical judgment
Learning continuity	Learning flow is easily disrupted when instructor attention is divided or human presence is limited	AI supports continuity of engagement and interaction beyond immediate instructor availability

Therefore, in immersive language learning con－texts such as MSI, the relative absence of such system－level support can be conceptualized as a design gap rather than a pedagogical failure. Examining how learners and instructors navigate this gap offers a productive lens for understanding the engagement, interaction, and instructional burden in AI－limited immersive environments.

Ⅲ. Methodology

1. Research Design and Context

This study adopts a qualitative single－case research design to examine how learner engage－ment and instructional burden are jointly shaped in a metaverse－based language learning environment. Rather than evaluating the technical performance of the platform or testing the effectiveness of specific instructional interventions, the study fo－cuses on the lived experience of a learner inter－acting with the Metaverse Sejong Institute (MSI). The case is treated not as statistically repre－sentative, but as analytically revealing, offering insight into structural characteristics of immersive language learning environments where system－level support is limited.

The research context is the Metaverse Sejong Institute (MSI), a mirror world type virtual learning environment launched in 2023 by the King Sejong Institute Foundation as part of Korea’s national initiative to expand digital Korean language education. Built on the ZEP platform, MSI recre－ates familiar Korean cultural and social spaces－

such as markets, parks, and urban streets—within a two-dimensional isometric virtual environment. MSI combines structured, real-time speaking courses conducted by certified Korean language instructors with opportunities for open exploration of cultural spaces through avatar-based interaction.

Despite its immersive spatial design and synchronous interaction, MSI currently operates without embedded AI-driven support systems, such as intelligent tutoring, conversational agents, or adaptive navigation guidance, making it a suitable context for examining immersive learning in AI-limited conditions. As shown in Figure 2, the platform comprises multiple interconnected spaces that support diverse modes of engagement, from formal classroom settings to open cultural exploration areas.

[Figure 2] Overview ofMetaverse Sejong Institute (MSI) learning environment. Screenshot captured by the author using the MSIplatform(ZEP-based) in 2024

The main image presents the overall spatial layout of the MSI environment, distinguishing between the instructional and exploratory zones, while the inset illustrates a representative learning scene captured during platform use.

2. Participants and Data Collection

The participant was a male learner in his early thirties with advanced proficiency in Korean. He had studied and lived in Korea for over seven years and completed both undergraduate and graduate education in Korea. The participant's advanced proficiency was a deliberate selection criterion intended to minimize the influence of linguistic limitations and foreground issues related to platform design, usability, and interactional structure. Although he had prior experience with online and video-based Korean language instruction, his exposure to metaverse-based learning environments was limited.

Data were collected using a multi-stage qualitative procedure designed to capture both real-time interactions and retrospective reflections. First, the participants engaged in guided exploration of multiple MSI spaces, including structured classroom areas and open cultural environments. During this phase, he was encouraged to navigate the platform freely and interact with objects and spaces as he saw fit. Second, a think-aloud protocol was employed to capture the participant's immediate interpretations, hesitations, and decision-making processes while navigating the environment, allowing the identification of moments of engagement, uncertainty, and breakdown related to usability and interactional cues. Third, a post-exploration semi-structured interview was conducted to elicit the participant's reflections on engagement, cultural immersion, usability, and instructional support, including situations in which teacher intervention was perceived as necessary. All sessions were audio recorded and transcribed verbatim.

3. Analytical Procedure

The data analysis followed an iterative thematic approach informed by sensitizing concepts from research on immersive learning, usability, and cognitive load. Rather than applying a predetermined coding scheme, the analysis proceeded through the repeated reading of transcripts and systematic comparisons across navigation behaviors, verbalized comments, and interview responses. The analysis focused on how moments of engagement, hesitation, and breakdown emerged through interactions with the immersive environment.

Four interrelated analytical dimensions guided the analysis: (1) learner engagement and agency, examining how spatial autonomy influenced motivation and sustained participation; (2) cultural immersion and contextual scaffolding, focusing on how spatial design supported or constrained the interpretation of language use; (3) usability and extraneous cognitive load, particularly instances in which unclear affordance cues or navigation difficulties diverted attention away from the learning activity; and (4) interactional constraints and instructional dependency, identifying moments when limited system-level support increased reliance on teacher intervention.

For clarity and consistency, excerpts and observations presented in the Findings section are referenced using three data sources: interview excerpts (Interviews 1 and 2), real-time navigation observations documented during guided exploration (Observations 1 and 2), and researcher field notes recorded during and immediately after the sessions (Field notes 1 and 2). Visual materials, such as screenshots, are presented as figures and not treated as primary analytic data units.

Ⅳ. Findings

This section presents the findings of the qualitative case analysis organized around four interrelated themes: learner engagement and agency, cultural immersion through spatial design, usability-related extraneous cognitive load, and interactional constraints leading to increased instructional dependence. Together, these findings illustrate how immersive affordances at the MSI both enable and constrain learning in the absence of system-level scaffolding.

1. Learner Engagement and Agency Through Spatial Autonomy

A prominent finding concerns the learner's heightened engagement and sense of agency afforded by spatial autonomy. The participant repeatedly contrasted MSI with video-based instruction, describing the metaverse environment as "fun" and "not passive like Zoom." This distinction was primarily attributed to the ability to control an avatar, move freely across spaces, and choose points of attention, rather than waiting for instructor-directed turns (Interview 1).

Spatial movement itself functioned as an engagement mechanism. During open exploration, participants continued to navigate the environment even in the absence of explicit instructional prompts, indicating that the curiosity-driven movement sustained participation (Observation 1).

This contrasts with screen-based classes, in which engagement is typically limited to verbal responses or chat inputs.

However, agency is conditional, rather than absolute. Although freedom of movement initially increases motivation, it also requires learners to interpret the environment independently. Moments of uncertainty emerged when spatial cues did not clearly indicate possible actions. These transitions from confident exploration to hesitation recurred across sessions (Fieldnote 1).

2. Cultural Immersion and Spatial Scaffolding

The second finding pertains to the role of spatial design in supporting cultural immersion and contextual understanding. MSI mirror-world environments, such as traditional markets and urban streets, provide implicit cultural scaffolding. The participant reported that these spaces immediately evoked recognizable social situations, allowing him to situate language use within familiar contexts without an explicit explanation (Interview 1).

For example, when navigating a market-like space, the participant spontaneously associated the setting with transactional language and everyday expressions, commenting that "you already know what kind of Korean belongs here." This suggested that the environmental context supported pragmatic interpretation and meaning making through visual and spatial cues rather than instructional input (Observation 2).

Notably, this scaffolding was experiential rather than procedural. The environment guided interpretation did not direct action, leaving the learner to infer how to engage linguistically within the space (Fieldnote 2).

3. Usability Friction and Extraneous Cognitive Load

Despite high initial engagement, usability issues introduced an extraneous cognitive load that disrupted the learning activity. The most salient issue was affordance ambiguity. Numerous objects appeared interactive, but produced no response when approached or clicked, while other interactive elements lacked visual indicators that distinguished them from non-functional objects (Observation 3).

As shown in Figure 3, this ambiguity manifested across multiple interface elements, forcing learners to distinguish between genuinely interactive objects and static environmental features.

[Figure 3] Examples of affordance ambiguity in the Metaverse Sejong Institute (MSI)

In response to these ambiguities, the participant frequently resorted to trial-and-error exploration, pausing to test possible actions and verbalizing uncertainty about the system behavior. During this period, attention shifted from language use to system interpretations. As the participant remarked, he was "thinking about how the platform works, not about Korean"(Interview 2).

Navigational inconsistencies further compounded this effect, interrupting the flow of exploration and requiring repeated cognitive recalibration (Fieldnote 3). Importantly, these difficulties occurred despite the participant's advanced language proficiency, underscoring that the observed cognitive load stemmed from the interface design rather than linguistic complexity (Kaplan-Rakowski & Gruber, 2023).

4. Interactional Constraints and Increased Instructional Dependence

The final finding concerns interactional limitations and their implications for instructional burden. MSI relies heavily on synchronous human presence to sustain interactions. When few users were online, the participant described the environment as feeling "empty"or "like a ghost town," noting that the absence of interaction partners significantly reduced the educational value of exploration (Interview 2).

Even when other users were present, initiating interaction was not straightforward. The participant hesitated to approach others without clear cues indicating availability or expected behavior, particularly when the instructor appeared to be occupied with another learner (Observation 4). At such moments, the platform provided no alternative interactional support, such as prompts or system-generated tasks.

As a result, the instructional responsibility shifted toward the teacher, who became the primary agent for restoring interactional flow through direct intervention (Fieldnote 4). This pattern reveals a structural dependency; in the absence of system-level scaffolding, immersive environments may paradoxically increase reliance on teacher intervention to sustain engagement.

<Table 2> Redistribution of instructional responsibility in AI-limited immersive environments

Instructional function	AI-limited environment	Instructor burden
Navigation & orientation	Learners rely on teacher explanations for spatial movement and task entry	Repeated spatial guidance and technical troubleshooting
Interaction initiation	Interaction depends on teacher mediation	Orchestrating participation and managing turn-taking
Affordance interpretation	Learners engage in trial-and-error exploration due to unclear cues	Explaining system behavior and clarifying task relevance
Breakdown repair	No system-level recovery mechanisms	Real-time intervention to restore interaction flow

Table 2 summarizes the redistribution of instructional responsibilities to instructors in the absence of system-level AI support.

5. Summary of Findings

Taken together, these findings indicate that MSI effectively promotes engagement through spatial autonomy and cultural immersion; however, these benefits are fragile and contingent on usability clarity and interactional support. When affordances are ambiguous or interaction pathways collapse, the cognitive load increases, and the instructional responsibility is redistributed to the teacher. These dynamics highlight a central tension in immersive language learning environments operating without AI-supported scaffolding; despite being designed to enhance learner agency, they may simultaneously intensify teacher burden.

Ⅴ. Discussion and Conclusion

This study examined how learner engagement and instructional burden are jointly shaped in a metaverse-based language learning environment through a qualitative case analysis of the Metaverse Sejong Institute (MSI).

The findings indicate that immersive spatial design and culturally contextualized environments can foster learner presence, agency, and curiosity-driven participation. Compared with screen-based instruction, the metaverse environment encouraged learners to remain active through movement and exploration.

It is important to note that this study does not directly examine instructors' subjective experiences of burden or workload. Rather, teacher burden is used as an analytical construct to describe a system-level redistribution of instructional roles and responsibilities resulting from limited AI-supported scaffolding. As such, the findings should be interpreted as illustrating structural conditions of immersive learning environments rather than as evidence of instructors' psychological or emotional burden. In addition, given the single-case design, the study does not aim for statistical generalization but instead offers analytically grounded insights into the interactional and infrastructural challenges characteristic of AI-limited metaverse-based language education.

However, engagement proved to be highly contingent. When affordance cues and interaction pathways were unclear, moments of active participation were repeatedly interrupted by hesitation and breakdown. These patterns suggest that immersion alone does not guarantee pedagogical effectiveness; rather, sustained engagement depends on how clearly learners are supported in interpreting and acting upon environmental cues. From this perspective, usability and interaction design emerge as core pedagogical conditions rather than secondary technical considerations.

Taken together, this case analysis highlights a central tension in AI-supported higher education: immersive learning environments are often introduced with the expectation of enhanced learner autonomy and engagement, yet in the absence of system-level intelligent support, these environments can inadvertently intensify instructional burden. The findings suggest that usability ambiguity and interactional fragility are not peripheral implementation issues but structural conditions that shape how learning and teaching unfold in immersive settings. From this perspective, AI should not be understood merely as an add-on for automation or personalization, but as pedagogical infrastructure that stabilizes interaction, distributes cognitive demands, and sustains engagement beyond continuous human mediation. As higher education increasingly turns to metaverse-based platforms, the pedagogical viability of such environments will depend less on techno-logical immersion itself than on how intelligently designed support systems align immersive affor-dances with sustainable teaching and learning practices.

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메타버스 기반 한국어 학습 플랫폼에서의 학습자 참여와 교수자 부담:

AI 지원 한국어교육에 대한 시사점

김은호

서울사이버대학교

본 연구는 메타버스 기반 한국어 학습 환경에서 학습자 참여와 교수자 부담이 형성되는 과정을 질적으로 탐구하고, 인공지능(AI) 지원 교육의 역할을 재조명하고자 한다. 이를 위해 메타버스 세종학당(Metaverse Sejong Institute, MSI)에 참여한 고급 한국어 학습자 1명을 대상으로 사례 분석을 수행하였다. 분석 결과, MSI는 공간적 자율성과 문화적 맥락을 제공함으로써 학습자의 몰입과 능동적 참여를 효과적으로 이끌어내는 것으로 나타났다. 그러나 직관적이지 못한 인터페이스 설계와 실시간 상호작용 지원 체계의 부재는 학습자에게 불필요한 인지적 부하를 야기했고, 이는 곧 교수자에게 전가되는 구조적 한계로 이어졌다. 특히 AI 기반 내비게이션 안내, 상호작용 매개, 즉각적 피드백 등 시스템 차원의 지원이 부족한 상황에서, 교수자는 학습 설계자를 넘어 상호작용 조율자 및 기술적 중재자로서 복합적 역할을 수행해야 했다. 본 연구는 이러한 분석을 바탕으로, 메타버스 기반 교육 환경에서 AI를 단순한 보조 도구가 아닌 학습 및 교수 활동을 체계적으로 뒷받침하는 교육 인프라(pedagogical infrastructure)로 재개념화할 필요가 있음을 제안한다.

주요어: 인공지능, 메타버스, 학습자 참여, 교수자 부담, 교육 인프라, 한국어교육