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BEYOND ACCESSIBILITY: REBUILDING LEARNER AUTONOMY THROUGH IMMERSIVE ADAPTIVE LEARNING IN THE DIGITAL TRANSFORMATION OF INCLUSIVE HIGHER EDUCATION

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ABSTRACT

Digital transformation drives the use of immersive technology and adaptive learning in higher education to create more personalized and inclusive learning experiences. This study aims to explore the meaning of learner agency in adaptive learning experiences based on immersive technology within the context of inclusive higher education. The study employs a phenomenological qualitative approach involving students participating in immersive technology-based learning. Data were collected through in-depth interviews, observations, and documentation, and analyzed using thematic analysis. The findings yielded four main themes: (1) the transformation of the learning experience from access to meaningful participation, (2) personalized learning as the foundation of learning autonomy, (3) immersive technology as a space for the reconstruction of academic identity, and (4) challenges to inclusivity within the digital learning ecosystem. The findings indicate that adaptive learning based on immersive technology enhances student engagement, autonomy, and self-confidence, while simultaneously strengthening participation in a more inclusive learning environment. However, limitations in accessibility and infrastructure remain implementation challenges. This study contributes to the development of research on learner agency in digital higher education and serves as a foundation for the development of more adaptive and inclusive policies and learning designs.

Keywords: learner agency; adaptive learning; immersive technology

INTRODUCTION

Digital transformation has become a global phenomenon that has significantly reshaped the paradigm of higher education in the 21st century. Advances in digital technology such as artificial intelligence (AI), big data analytics, the Internet of Things (IoT), cloud computing, and immersive technologies based on Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) have driven fundamental changes in how educational institutions design, manage, and deliver the learning process. This shift is not only related to the digitization of learning resources but also involves a shift in educational philosophy from teacher-centered learning toward student-centered learning, which positions students as the primary agents in the process of knowledge construction [1]. In this context, technology is no longer viewed merely as a learning tool but as an ecosystem that shapes learning experiences, social interactions, and the continuous development of students' competencies.

This transformation is increasingly relevant in the era of Society 5.0, which emphasizes the integration of physical and digital spaces to create a more inclusive and human-centered society. The concept of Society 5.0 requires higher education to produce graduates who not only possess academic and digital competencies but also adaptive, creative, and collaborative skills, as well as the ability to engage in lifelong independent learning. Within this framework, higher education is required to develop learning systems capable of accommodating the diversity of students' needs, characteristics, and learning styles through a more personalized and flexible approach. Changes in the global higher education landscape are also influenced by growing demands for inclusive education as part of the Sustainable Development Goals (SDGs) agenda, particularly the fourth goal regarding quality, inclusive, and equitable education for all. Inclusive education is no longer understood merely as providing physical access to education, but rather encompasses an institution's ability to create learning experiences that are equitable, meaningful, and empowering for all students, regardless of their social, economic, or cultural background, or their physical and cognitive abilities. Thus, digital transformation and inclusive education have become two interrelated priorities in the future development of higher education.

Although many universities have widely adopted digital technology, various studies indicate that the implementation of digital transformation has not yet fully resulted in an inclusive learning experience. Many online learning platforms are still designed based on the assumption that all students have relatively uniform needs and abilities. As a result, students with diverse learning needs often face difficulties in accessing materials, participating in learning activities, or engaging optimally within the digital academic environment [2]. This situation indicates that the digitization of education does not automatically guarantee inclusivity if instructional design fails to account for the diversity of student characteristics.

In Indonesia, the issue of inclusive higher education is gaining increasing attention as awareness of the right to education for all citizens grows. Various universities have established disability service centers, provided digital accessibility facilities, and implemented learning management systems (LMS). However, various studies indicate that students with disabilities and those with special learning needs still face numerous barriers in participating in learning processes that are largely designed in a uniform manner. These barriers include limited technological accessibility, a lack of adaptation of learning materials, and a scarcity of pedagogical support tailored to students' individual needs.

Advances in immersive technology offer new opportunities to address these challenges. Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) technologies enable the creation of learning experiences that are more contextual, interactive, and multisensory. Through these technologies, students can interact directly with virtual environment simulations that resemble real-world conditions, thereby enabling deeper experiential learning. The use of immersive technologies can also visualize abstract concepts that are difficult to explain through conventional learning methods, thereby enhancing students' conceptual understanding [3]. Various studies indicate that immersive technology can enhance learning motivation, academic engagement, and the quality of

student interactions in the learning process. A systematic review conducted by the “ found that the use of Extended Reality (XR) in higher education has a positive impact on students’ active participation, problem-solving skills, and a more authentic learning experience. These findings demonstrate that immersive technology has the potential to serve as a vital tool in supporting a more meaningful and student-centered transformation of learning.

In addition to improving the quality of learning, immersive technology also has the potential to strengthen the implementation of inclusive education. Virtual learning environments allow information to be presented in a variety of visual, auditory, textual, and interactive formats that can be tailored to users’ needs. This multimodal nature provides opportunities for students with diverse learning needs to have a more equitable learning experience compared to traditional learning models. Thus, immersive technology has the potential to reduce barriers to learning while expanding student participation in the academic environment.

Research from the " shows that the use of Virtual Reality can help students with intellectual disabilities and autism understand scientific concepts through more concrete three-dimensional visualizations. The results of this study demonstrate that immersive technology not only enhances conceptual understanding but also expands learning opportunities for students who have previously faced limitations in accessing conventional learning. These findings reinforce the argument that immersive technology can serve as an instrument of inclusion in higher education.

Furthermore, the development of the metaverse concept in education also presents new opportunities for creating more inclusive and collaborative learning environments. The study found that students with disabilities view the metaverse environment as a learning space with the potential to enhance empowerment, engagement, accessibility, and social participation. Students believe that avatar representation, the flexibility of the virtual environment, , and the ability to customize the learning experience can help reduce the barriers they have faced in conventional classrooms.

Despite its many potential benefits, the implementation of immersive technology in higher education still faces various challenges. A systematic review conducted by the " indicates that the primary barriers to the implementation of immersive technology no longer lie solely in technological aspects, but rather in pedagogical readiness, faculty competence, institutional support, and the availability of learning frameworks capable of effectively integrating technology. In other words, the success of digital transformation depends heavily on how the technology is interpreted and used in the context of learning.

Furthermore, various studies indicate that students’ experiences in digital learning environments are influenced not only by technological features but also by subjective experiences, perceptions, emotions, identity, and social interactions that develop throughout the learning process. Therefore, understanding the digital transformation of education requires attention to the human dimensions that are often overlooked in technology-based studies.

In recent years, advancements in artificial intelligence have spurred the emergence of adaptive learning as a strategic approach in digital higher education. Adaptive learning is

a system that tailors course content, activities, learning paths, the pace of learning, and feedback to the individual characteristics and needs of students. This approach enables the creation of a learning experience that is more personalized and responsive to the diversity of learners.

Adaptive learning is becoming increasingly important in the context of inclusive education because it provides students with the opportunity to learn according to their individual abilities, preferences, and needs. Adaptive systems allow students to receive tailored learning support based on their specific circumstances, thereby helping to reduce disparities in learning outcomes. In this context, technology serves not only as a medium for conveying information but also as a facilitator that supports students' independence and learning success.

However, most research on adaptive learning remains focused on measuring the effectiveness of the technology, improvements in learning outcomes, and students' academic performance. Studies exploring students' subjective experiences when interacting with adaptive learning systems based on immersive technology are still relatively limited. Yet, user experience is a crucial aspect in understanding how students construct meaning from the learning processes they undergo.

These limitations are further highlighted by the predominant use of quantitative and experimental approaches in educational technology research. Most studies focus on measuring variables such as motivation, satisfaction, engagement, and learning outcomes using statistical instruments. Although these approaches provide important information regarding the effectiveness of technology, they have not been able to explain in depth how students interpret their learning experiences, how they adapt to the digital environment, and how technology influences their academic identity and learning autonomy.

From a social constructivist perspective, learning is an active process that involves the construction of meaning through an individual's interaction with their surrounding social and cultural environment. Therefore, learning experiences in immersive digital environments cannot be understood solely through academic performance indicators, but also through the processes of reflection, interpretation, and negotiation of meaning undertaken by students as they interact with technology. This approach positions students as active agents who construct their own academic experiences and identities.

In line with this perspective, the concept of learner agency has become a central issue in the digital transformation of higher education. Learner agency refers to students' ability to make decisions, devise learning strategies, set academic goals, and independently manage the learning process. In an increasingly complex digital learning environment, learner agency serves as a key indicator of the extent to which students are able to act as active and autonomous learners.

The use of immersive technology and adaptive learning has the potential to strengthen learner agency by providing students with greater control over their own learning experiences. However, there has been little research explaining how learner agency is formed, developed, and interpreted by students in the context of adaptive learning using immersive technology. This research gap highlights the need to explore the dimensions of students' lived experiences in greater depth.

Furthermore, recent literature also indicates that issues of accessibility, user empowerment, digital privacy, and psychological safety are key components in the development of inclusive immersive learning environments [4]. Thus, discussions regarding learner agency cannot be separated from the social, cultural, and technological contexts that shape students' learning experiences in digital spaces.

Based on the above discussion, there is a research gap indicating that studies on adaptive learning, immersive technology, and inclusive education are still dominated by technological and quantitative perspectives. Research exploring students' subjective experiences in developing learning autonomy through interactions with immersive technologies remains relatively limited. Yet, understanding these experiences is crucial for developing digital learning models that are more human-centered, inclusive, and student-centered.

Therefore, this study aims to explore and reconstruct the meaning of learner agency in adaptive learning experiences based on immersive technology within the context of inclusive higher education. The research focuses on how students interpret their interactions with immersive technology, how these experiences influence their learning autonomy, and how digital transformation shapes educational experiences that are inclusive and empowering. Theoretically, this study is expected to enrich the literature on learner agency, adaptive learning, immersive technology, and digital inclusive education through a qualitative perspective. Practically, the research findings are expected to serve as a foundation for the development of educational policies, instructional design, and technological innovations that are more adaptive, human-centered, and capable of accommodating the diverse needs of students in the era of digital transformation.

Literature Review / Theoretical Foundation

Digital Transformation in Higher Education

Digital transformation is a strategic change process involving the integration of digital technology into all aspects of an organization to bring about fundamental changes in how the institution operates, creates value, and delivers services to stakeholders. In the context of higher education, digital transformation is not merely understood as the digitization of learning processes but encompasses changes in educational paradigms, academic culture, institutional governance, curriculum, evaluation systems, and the overall student learning experience [5].

Advances in digital technology have created an increasingly complex and dynamic learning ecosystem. The emergence of artificial intelligence (AI), the Internet of Things (IoT), big data analytics, blockchain, cloud computing, and immersive technologies has transformed the way students acquire, process, and construct knowledge. Higher education institutions no longer function as the sole source of information but have transformed into learning facilitators that enable students to access learning resources from various digital environments.

According to the perspective of Digital Transformation Theory, digital transformation is a sociotechnical change involving the interaction between people, technology, organizations, and culture. [6] explains that digital transformation focuses not only on the implementation of technology, but also on how technology shapes social

practices, user behavior, and patterns of interaction within organizations. In higher education, digital transformation is changing the relationship between faculty, students, knowledge, and the learning environment.

The COVID-19 pandemic has been the primary catalyst for accelerating digital transformation in the education sector. Various higher education institutions were forced to adopt online learning in a short period, thereby driving the emergence of various technology-based pedagogical innovations. This experience demonstrates that digital technology is no longer an alternative but an integral part of the modern education system[7]

In the context of Society 5.0, the digital transformation of education is directed toward the development of a human-centered learning system. Technology is developed not merely to enhance efficiency, but to support the optimal development of human potential. Therefore, the success of digital transformation is not measured solely by technology adoption, but also by improvements in the quality of the learning experience, inclusivity, user well-being, and the empowerment of learners.

The human-centered digital transformation perspective emphasizes that technology must be able to accommodate the diverse needs of students. A successful digital transformation is one that enables all students to have equal, meaningful, and relevant learning opportunities tailored to their needs. Thus, the issue of inclusivity is an integral part of the higher education digital transformation agenda.

Inclusive Higher Education

Inclusive education is an educational approach that ensures every individual has equal opportunities to access, participate in, and succeed in the educational process without discrimination based on physical, intellectual, social, cultural, economic, or other characteristics. (defines inclusive education as the process of identifying and removing barriers that limit student participation so that all individuals can have an equal learning experience.

In higher education, the concept of inclusivity extends beyond the provision of physical and administrative access. Inclusive higher education requires the creation of an academic environment that enables all students to actively participate in the learning process, personal development, research, and campus life as a whole.

According to Social Inclusion Theory, inclusivity is not only about an individual's presence within a system, but also about the extent to which that individual feels accepted, valued, has a voice, and can contribute meaningfully to their social community. In the context of higher education, it is not enough for students to simply be present in the classroom; they must also have the opportunity to actively engage in the learning process[8]

Modern inclusive education models are heavily influenced by the concept of Universal Design for Learning (UDL) developed by CAST. UDL emphasizes the importance of providing diverse forms of information representation, various ways for students to demonstrate their understanding, and a range of strategies to enhance learning engagement. This approach enables educational institutions to design learning environments capable of accommodating the diversity of student needs from the outset

without having to make individual modifications [9] .

In the digital environment, inclusivity also encompasses the aspects of digital accessibility, digital participation, and digital equity. These three aspects are important because students have varying levels of digital literacy, access to technology, and learning needs. Therefore, digital learning design must take into account the principles of accessibility, flexibility, and adaptability.

Recent research indicates that the primary challenge of inclusive higher education is no longer merely access to education, but the quality of the learning experience students have. Students with special needs often face psychological, social, and academic barriers even though they have formally gained equal access to education. Therefore, an inclusive approach must take into account students' subjective experiences as a crucial part of the learning process.

Immersive Technology in Learning

Immersive technology is a technology that allows users to experience a sense of presence in a digital environment through intensive multisensory interaction. This technology includes Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and Extended Reality (XR), which are capable of simultaneously integrating the physical and virtual worlds [10] .

Virtual Reality creates a fully digital environment that allows users to interact directly with virtual objects. Augmented Reality adds digital elements to the real environment, while Mixed Reality enables a more complex integration between virtual objects and the physical world. Current developments in XR combine these various forms of technology into a single learning ecosystem that is increasingly realistic and interactive.

According to Radianti et al. immersive technology has three main characteristics: immersion, interaction, and imagination. These three characteristics enable students to have a more contextual learning experience compared to conventional learning.

The theoretical foundation for the use of immersive technology can be explained through the Experiential Learning Theory developed by [12] . This theory states that learning occurs through a process of concrete experience, reflection, abstract conceptualization, and active experimentation. Virtual environments allow students to gain experiences that resemble real-life situations, thereby strengthening the experiential learning process.

In addition, the theory of constructivism developed by [8] explains that knowledge is constructed through individuals' active interaction with their environment. In this context, immersive technology provides an environment that enables students to construct knowledge through exploration, simulation, and collaboration.

Recent research shows that the use of immersive technology can enhance learning motivation, academic engagement, critical thinking skills, problem-solving abilities, and knowledge retention. This technology also allows students to access learning experiences that are difficult to replicate through traditional teaching methods, such as high-risk laboratory simulations, exploration of historical environments, or virtual clinical practice.

In inclusive education, immersive technology offers opportunities to create learning environments that are more flexible, multimodal, and responsive to the diverse needs of students. Information can be presented through a combination of visual, auditory,

kinesthetic, and interactive elements, allowing students to learn according to their individual preferences and needs.

Adaptive Learning

Adaptive learning is an educational approach that uses digital technology and artificial intelligence to tailor the learning experience based on the individual characteristics, abilities, preferences, and progress of each learner. Adaptive learning is based on the assumption that every individual has different learning needs. Therefore, an effective learning process must be able to adapt the content, level of difficulty, learning strategies, and feedback to suit the learner's specific circumstances.

According to [13], Artificial Intelligence-based adaptive learning utilizes algorithms to analyze students' learning patterns in real time. The system then uses this information to provide recommendations for the most suitable learning materials, activities, and strategies for each user. The theoretical foundation of adaptive learning can be explained through the theory of Personalized Learning, which places the learner at the center of the learning process. This theory emphasizes the importance of flexibility in the delivery of material, learning pace, and evaluation methods so that each student can reach their full potential.

In addition, adaptive learning is also linked to the Self-Regulated Learning Theory developed by [14]. This theory explains that learning success is greatly influenced by an individual's ability to manage goals, monitor progress, and reflect on the learning process. In the context of inclusive education, adaptive learning is highly relevant because it enables automatic differentiation of instruction. Students with varying abilities can receive tailored learning paths without having to follow a uniform learning model.

Nevertheless, several studies indicate that the success of adaptive learning depends not only on the sophistication of the technology but also on students' ability to actively engage with the system. Therefore, adaptive learning should be understood as a process of interaction between technology and users, rather than merely an automated mechanism controlled by algorithms.

Learner Agency as the Primary Theoretical Perspective

Learner agency is a concept that refers to an individual's capacity to act consciously, make decisions, manage the learning process, and influence their own learning environment. This concept is becoming increasingly important in digital higher education because students are expected to act as independent and proactive learners.

Theoretically, learner agency is rooted in Social Cognitive Theory developed by Bandura. According to [15], humans are active agents who have the ability to regulate their actions, reflect on their experiences, and influence their social environment. Agency does not only mean the freedom to act, but also the ability to direct oneself toward specific goals.

In the context of higher education, learner agency encompasses students' ability to set learning goals, choose learning strategies, utilize available resources, engage in self-reflection, and make decisions related to their learning process.

From a sociocultural perspective, learner agency is shaped through interactions between individuals, technology, the social environment, and cultural contexts. Therefore,

agency is not a fixed individual characteristic but rather a construct that develops through a person's learning experiences.

Adaptive learning and immersive technology provide conditions that foster the development of learner agency. A flexible learning environment gives students the opportunity to determine their own learning paths, engage in independent exploration, and build understanding based on direct experience.

In this study, learner agency is used as the primary theoretical lens to understand how students interpret their learning experiences in an adaptive learning environment based on immersive technology. Agency is viewed as the result of a dynamic interaction between technology, learning experiences, and the surrounding context of inclusive education.

The literature review in this study indicates that research on digital transformation, adaptive learning, immersive technologies, and inclusive education has grown significantly over the past five years. However, most studies still focus on evaluating the effectiveness of technology, improving learning outcomes, and the technical aspects of implementation.

Radianti found that Virtual Reality can enhance student engagement in learning, but the study did not explain how this experience fosters students' independent learning [16]. indicates that digital technology and the metaverse have the potential to improve educational accessibility for students with special needs. However, the research focus remains on technological and accessibility aspects.

highlights the challenges of implementing immersive technologies related to accessibility and inclusive design. However, this research has not yet explored how students interpret their experiences using these technologies in their academic lives[17].

Thus, there is a gap in the literature regarding students' subjective experiences in developing learner agency through adaptive learning based on immersive technology in the context of inclusive higher education. The theoretical gap in this research lies in the lack of integration of the concepts of digital transformation, inclusive education, immersive technology, adaptive learning, and learner agency into a single, cohesive conceptual framework. Most studies view students as users of technology, rather than as active agents who construct meaning and develop learning capacities through interaction with technology.

A methodological gap is evident in the dominance of quantitative and experimental approaches that focus on learning outcomes, system effectiveness, and user satisfaction levels. Meanwhile, in-depth exploration of students' lived experiences in immersive learning environments remains relatively limited.

Based on a synthesis of theory and prior research, this study positions learner agency as a core concept shaped by the interaction between immersive technology, adaptive learning, and an inclusive higher education environment. This interaction generates learning experiences that have the potential to strengthen students' autonomy, active participation, control over their learning, and empowerment as they navigate the digital transformation of higher education.

METHODS

This study employs a qualitative approach using *Interpretative Phenomenological*

Analysis (IPA) to gain an in-depth understanding of students' experiences in interpreting adaptive learning based on immersive technology within the context of inclusive higher education. The phenomenological approach was chosen because this study focuses on exploring participants' *lived experiences*, perceptions, and constructions of meaning regarding the use of digital technology in the learning process. The research was conducted at several universities that have implemented immersive technologies, such as *Virtual Reality (VR)*, *Augmented Reality (AR)*, and artificial intelligence-based adaptive learning platforms, during the period of January– June 2026. The research participants consisted of 15 students selected using *purposive sampling* based on the following criteria: (1) currently enrolled in higher education, (2) having at least one semester of experience using immersive technologies in learning,

(3) involved in an adaptive learning system, and (4) willing to participate voluntarily. To expand the pool of relevant informants, snowball sampling was employed based on recommendations from initial participants who met the study's criteria [18] ; [19]

Data collection was conducted through semi-structured interviews as the primary method for exploring participants' experiences, perceptions, and reflections regarding immersive adaptive learning. Each interview lasted 60–90 minutes and was recorded with the participants' consent. Additionally, non-participant observation was conducted to understand students' interactions with the digital learning environment, while documentation was used to examine institutional policies, platform usage guidelines, and other relevant supporting documents. To enhance data credibility, this study employed methodological triangulation through a combination of interviews, observation, and documentation, as well as source triangulation by comparing information from various participants with differing characteristics. Data validation was also conducted through member checking—returning summaries of interview results to participants to confirm the accuracy of the researcher's interpretations—and an audit trail to systematically and transparently document the entire research process [20] ; [21]

Data analysis was conducted using the Interpretative Phenomenological Analysis approach developed by Smith, Flowers, and Larkin. The analysis process began with repeated readings of the entire interview transcripts to gain a comprehensive understanding of the participants' experiences. This was followed by initial coding through the recording of descriptive, linguistic, and conceptual- al comments, which were then developed into emergent themes. These themes were analyzed iteratively to identify patterns of relationships that describe the process of learner agency formation within an adaptive learning environment based on immersive technology. The final stage involved interpreting the findings based on a theoretical framework encompassing digital transformation in education, inclusive higher education, immersive technology, adaptive learning, and social constructivism. The analysis process was conducted reflectively and continuously to generate a deep understanding of students' experiences in building learning autonomy in the era of digital transformation in higher education [22] ; [19]

RESULTS AND DISCUSSION

Research Findings

Analysis of data obtained through in-depth interviews, participatory observation, and document analysis yielded four main themes that describe students' experiences in interpreting adaptive learning based on immersive technology within the context of inclusive higher education. These four themes include: (1) the transformation of learning experiences from access to meaningful participation, (2) personalized learning as the foundation of learning autonomy, (3) immersive technology as a space for the reconstruction of academic identity, and (4) the challenges of inclusivity within the digital learning ecosystem. These four themes do not stand alone but are interconnected and shape students' learning experiences holistically within a digitized educational environment.

Research findings indicate that students do not view technology merely as a learning aid, but as an integral part of the learning environment that actively influences how they acquire knowledge, build academic identity, and develop learning autonomy. The experiences they construct while interacting with adaptive and immersive technologies reveal a shift in the learning paradigm from merely receiving information to an active process involving reflection, exploration, decision-making, and social participation.

Transformation of the Learning Experience: From Access to Meaningful Participation

The first theme describes a fundamental shift in how students perceive the learning process when interacting with immersive technology. Before using immersive technology-based learning environments, most participants described their learning experiences as largely passive activities. Learning was dominated by lectures, presentations, and reading activities that often reduced students to mere recipients of information.

Some participants noted that in conventional learning, they often struggled to grasp abstract concepts, particularly in material requiring spatial visualization, process simulations, or contextual experiences that could not be directly replicated in the classroom. Consequently, the learning process relied heavily on students' ability to visualize the concepts explained by instructors.

The presence of immersive technology significantly transforms this experience. Students no longer merely view visual representations through images or videos but can directly interact with objects, environments, and simulations that resemble real-world conditions. This interaction allows students to build understanding through direct experience, making the learning process more active and meaningful.

One participant explained:

"Before, I would just read or look at images on slides. When using VR simulations, I feel like I'm right in the middle of the situation being studied. It makes it easier for me to understand and remember the material."

This statement indicates that the learning experience is no longer limited to the transfer of information but has evolved into an experience that simultaneously involves cognitive, emotional, and sensory engagement. Students feel a sense of closeness to the learning objects, making previously abstract concepts more concrete and easier to

understand.

Observations conducted during the learning process also revealed changes in students' interaction patterns. In sessions using immersive technology, students were seen to be more active in asking questions, discussing, and exploring various possibilities available within the virtual environment. Learning activities are no longer centered on the instructor as the primary source of knowledge but have evolved into a collaborative process involving interaction among students, technology, and the learning environment.

In addition to enhancing academic engagement, immersive technology also creates a more personalized and emotionally engaging learning experience. Some participants reported feeling more "connected" to the learning material because they could experience situations that had previously been studied only in theory. These experiences fostered curiosity, intrinsic motivation, and a greater interest in the subject matter.

For students with diverse learning needs, immersive environments also provide opportunities to learn through various representations of information. Some participants explained that 3D visualizations, interactive simulations, and immediate feedback helped them understand the material in ways better suited to their individual learning styles.

Overall, this theme demonstrates that digital transformation not only expands access to learning resources but also transforms the learning experience from a passive activity into meaningful participation. Students no longer merely receive information but actively engage in building knowledge through more contextual and authentic experiences.

Personalized Learning as the Foundation of Independent Learning

The second theme relates to students' experiences using adaptive learning systems capable of tailoring the learning process to individual needs, abilities, and progress. Nearly all participants stated that personalization features were one of the most influential aspects of their learning experience.

Students explained that adaptive systems allow them to learn at their own pace without having to follow a uniform learning speed. This provides students with greater flexibility to deeply understand the material before moving on to the next stage.

One participant stated:

"The system provides additional material when I encounter difficulties and immediately presents new challenges once I've mastered the previous material. I feel more responsible for my own learning process."

This statement indicates that personalized learning serves not only as a technical mechanism for tailoring course materials but also influences how students view their role in the learning process. Students begin to see themselves as active participants who have control over their learning, rather than merely following instructions set by the instructor.

Some participants noted that before using the adaptive system, they often felt left behind when the material was presented too quickly or felt bored when the pace of learning was too slow. The availability of a system that can adjust the difficulty level and pace of learning helps alleviate that pressure.

Another interesting finding shows that personalized learning fosters the development of self-reflection skills. Students become more aware of their strengths and weaknesses in learning. The information provided by the system regarding their learning

progress helps students evaluate their achievements more objectively.

Some participants explained that they began to develop more structured learning strategies after using the adaptive system. They actively set learning goals, selected additional learning resources, and scheduled their study time according to their individual needs. These changes indicate the emergence of stronger self-regulated learning skills compared to their previous learning experiences.

In addition, students also noted that adaptive learning provides a sense of security in their studies. They do not feel judged when they encounter difficulties because the system allows them to review the material or retry learning activities without the social pressure that often arises in face-to-face learning.

For students with special learning needs, personalized learning is a crucial aspect. Adaptive systems help them receive support better tailored to their individual circumstances, thereby enabling them to reduce the learning barriers they have previously faced in conventional learning.

Overall, this theme demonstrates that personalized learning serves as a key foundation for the development of learner agency. Through flexible and responsive learning experiences, students develop the ability to independently manage, direct, and evaluate their own learning processes.

Immersive Technology as a Space for Reconstructing Academic Identity

The third theme indicates that learning experiences in immersive environments not only influence students' cognitive aspects but also shape how they perceive themselves as learners. Many participants described the shifts in their academic identity following their engagement with immersive technology-based learning.

Some students who previously felt less confident in participating in learning expressed that the virtual environment provided a safer space to experiment and learn from mistakes. They no longer felt afraid of being judged by others when trying to complete tasks or answer questions.

One student stated:

"I used to be passive in class because I was afraid of making mistakes. In the virtual environment, I can try over and over again without feeling judged. That makes me more confident when discussing in class."

These findings suggest that immersive technology creates a psychological space that allows students to rebuild their academic self-confidence. The opportunity to try, fail, and correct mistakes repeatedly helps students develop a positive perception of their own abilities.

Students also reported that learning experiences in virtual environments made them feel more competent and capable of handling academic challenges. Realistic simulations provide opportunities to apply knowledge in situations resembling real-world conditions, thereby boosting their confidence in their future professional abilities.

Observations during the study showed that students who were initially passive began to demonstrate increased participation in group discussions, presentations, and collaborative activities after participating in immersive technology-based learning several times. These changes indicate that academic identity is not static but continues to evolve

through the learning experiences individuals undergo.

In addition to boosting self-confidence, immersive technology also helps students develop a sense of ownership over the learning process. They no longer view themselves as mere recipients of knowledge but as individuals capable of actively contributing to the process of knowledge construction.

For some participants, learning experiences in virtual environments even influenced their academic and professional aspirations. They felt better prepared to face the challenges of the professional world because they had gained simulated experiences that closely resembled real-world conditions.

Thus, immersive technology functions not only as a learning medium but also as a social and psychological space that allows students to reconstruct their academic identity as active, competent, and independent learners.

Challenges of Inclusivity in the Digital Learning Ecosystem

Although most participants reported positive experiences, this study also identified various challenges indicating that digital transformation has not yet fully created an inclusive learning environment. The first challenge relates to access to technological infrastructure. Some students noted that limitations in hardware, internet connection quality, and the cost of accessing technology remain barriers to participating in immersive technology-based learning.

One participant explained:

“The technology is very helpful, but not all students have adequate devices. Sometimes the learning experience becomes uneven due to facility factors.”

This finding suggests that digital transformation has the potential to create new forms of inequality if access to technology is not evenly distributed. Students with good devices and internet connections have a more optimal learning experience compared to those facing resource constraints.

Beyond infrastructure, another challenge relates to the readiness of educational institutions. Some participants noted that available technical support remains limited, leading students to frequently encounter difficulties when facing technical issues during the learning process.

Students also highlighted the lack of adequate training in the use of immersive technologies. Most participants had to learn independently to understand how to use the devices and applications employed in their learning.

For students with special needs, the challenges they face tend to be more complex. Some participants noted that the interface design and accessibility features of certain applications do not yet fully support their needs. This situation results in their learning experience not always being on par with that of other students.

In addition to technical barriers, this study also identified psychological challenges. Some students felt overwhelmed when they had to adapt to various new technologies within a relatively short period of time. This situation indicates that digital transformation requires adequate emotional and pedagogical support to enable students to adapt effectively.

Other findings indicate that the success of technology implementation is determined not only by the quality of the devices but also by the instructional design employed. Advanced technology does not always result in a positive learning experience if it is not

integrated with appropriate pedagogical strategies.

Overall, this theme highlights that digital transformation still faces various challenges in realizing truly inclusive higher education. Therefore, the development of educational technology must consider aspects of accessibility, equitable access, institutional readiness, pedagogical support, and the diverse needs of students so that the benefits of digital transformation can be felt equally by all learners.

Discussion

The research findings indicate that adaptive learning based on immersive technology has brought about significant transformations in students' learning experiences within an inclusive higher education environment. This transformation is evident not only in increased access to digital learning resources but also in changes in how students participate, construct meaning, and position themselves within the learning process. These findings indicate that the digital transformation of education cannot be understood merely as a process of technology adoption but rather as a shift in the learning ecosystem that simultaneously impacts students' cognitive, affective, social, and academic identity dimensions.

In general, the research results show that the integration of adaptive learning and immersive technology creates a learning environment that is more responsive to students' needs. This environment enables students to have a learning experience that is more personalized, contextual, and participatory compared to conventional learning models. These findings reinforce the argument that the success of digital transformation in education is determined not only by the sophistication of the technology used, but by the technology's ability to support meaningful learning experiences and empower learners.

Transforming the Learning Experience: From Access to Meaningful Participation

The first finding indicates that students perceive immersive technology as a tool that transforms the learning experience from merely accessing information to active engagement in the learning process. Before using immersive technology, most students described learning as an activity of receiving information delivered by instructors. However, when they interacted with an interactive virtual environment, students began to engage directly in processes of exploration, simulation, observation, and problem-solving.

This finding can be explained through the perspective of social constructivism developed by [23]. In this theory, learning is viewed as an active process that occurs through interaction between individuals and their social and cultural environment. Knowledge is not passively transferred from the instructor to the learner but is constructed through a process of meaning-making that takes place during that interaction. Immersive virtual environments provide a context that allows students to directly experience the objects and phenomena being studied, thereby making the knowledge-building process more authentic.

The results of this study are also consistent with Kolb's Experiential Learning Theory. This theory explains that effective learning occurs through a cycle of concrete experience, reflection, conceptualization, and active experimentation. Immersive technology enables students to gain concrete experiences that were previously difficult to achieve in a conventional classroom. Virtual simulations provide students with the

opportunity to observe, try, and reflect on experiences directly, thereby strengthening the conceptual understanding they build.

Furthermore, research findings indicate that immersive learning experiences result in higher levels of emotional engagement compared to conventional learning. Students not only understand the material intellectually but also experience an emotional connection to the learning context. This emotional engagement contributes to increased intrinsic motivation, curiosity, and the meaningfulness of the learning experience. This reinforces the view that effective learning is a process that involves both cognitive and affective aspects simultaneously.

These findings expand upon the results of the study ” , which concluded that Virtual Reality can enhance student engagement in higher education. This study demonstrates that this increased engagement occurs not only at the level of learning activities but also at the level of meaning construction. Students no longer view learning as merely an academic obligation but rather as an experience relevant to their needs, interests, and learning goals.

Personalization of Learning and the Development of Learner Agency

The second theme highlights that personalized learning is a key mechanism in fostering student agency. Adaptive learning systems enable students to follow different learning paths tailored to their individual abilities, needs, and learning progress. This flexibility provides students with greater autonomy to manage their own learning process.

These findings support the theory of personalized learning, which places students at the center of the entire learning process. In this approach, learning success is not determined by the uniformity of the process, but by the system's ability to accommodate the diversity of individual characteristics. The students involved in this study demonstrated that when they were given the opportunity to learn at their own pace and according to their individual needs, they became more active in making decisions regarding the learning strategies they employed.

The research findings also reveal a strong link between adaptive learning and Zimmerman's Self-Regulated Learning Theory. Students began to demonstrate the ability to set learning goals, monitor their progress, evaluate their results, and adjust their strategies when encountering difficulties. In other words, personalized learning not only enhances academic effectiveness but also develops self-regulation skills, which form the foundation of lifelong learning.

From the perspective of Social Cognitive Theory, these findings suggest that learner agency develops through the interaction of personal, environmental, and behavioral factors. Adaptive technology serves as a learning environment that provides students with opportunities to make decisions and take control of their own learning process. When students successfully manage their learning experiences independently, their self-efficacy increases, which in turn strengthens their belief in their own learning abilities.

Interestingly, this study found that learner agency does not emerge automatically as a result of technology use. Agency develops when students are given the space to make choices, reflect, and influence the course of the learning process. Thus, technology serves as a facilitator that creates opportunities for agency to emerge, while the development of

agency itself depends on the quality of the interactions between students and the learning environment.

These findings expand upon the results of the study “ , which emphasizes the benefits of adaptive learning in improving academic performance. This study demonstrates that the impact of adaptive learning extends beyond improved learning outcomes; it also contributes to the formation of students’ identities as independent, reflective learners who take responsibility for their own learning processes.

Immersive Technology and the Reconstruction of Academic Identity

One of the most intriguing findings in this study is the role of immersive technology in reshaping students’ academic identities. Most participants described changes in how they view themselves as learners after engaging in virtual simulation- based learning experiences.

From the perspective of social identity theory, academic identity is formed through an individual’s interaction with the social environment in which they learn. Virtual environments provide a new space that allows students to experiment, take risks, and learn from mistakes without facing the social pressures often present in traditional classrooms. These conditions create a psychological experience that supports the development of self-confidence and academic competence.

Research findings indicate that students who were previously passive and lacked self-confidence began to demonstrate the courage to participate in discussions, express their opinions, and take an active role in the learning process. These changes suggest that immersive technology functions not only as a learning tool but also as a social space that facilitates identity transformation.

From a constructivist perspective, academic identity is viewed as a continuously evolving construct shaped by experience and social interaction. The virtual environment provides students with the opportunity to construct a new narrative about themselves as individuals capable of learning, contributing, and successfully overcoming academic challenges. Thus, immersive technology has an impact that extends beyond the cognitive dimension, as it also influences students’ psychological and social development.

These findings expand upon previous research that has largely focused on enhancing motivation and learning engagement. This study demonstrates that immersive experiences can serve as a means of reconstructing academic identity, contributing to increased self-confidence, a sense of competence, and a sense of belonging among students in higher education settings.

Digital Inclusivity and the Paradox of Technological Transformation

Although the majority of students reported positive experiences, this study also identified various challenges that highlight a paradox in the digital transformation of education. On one hand, adaptive and immersive technologies can expand access, enhance personalized learning, and strengthen student participation. On the other hand, the same technologies have the potential to create new forms of inequality when access to devices, internet connectivity, and institutional support is not evenly distributed.

These findings reinforce the concept of the digital divide, which explains that the

digital divide is not only related to access to technology but also to the ability to utilize technology effectively. Students with limited devices or internet connectivity tend to have a different learning experience compared to students with more adequate technological resources.

From an inclusive education perspective, these findings indicate that accessibility should not be narrowly understood as merely the availability of technology. Accessibility must encompass the ability of all students to participate equally in the learning process. Therefore, digital inclusivity must be viewed as a combination of technological access, instructional design, institutional support, and user experience.

The research findings also show that some learning applications and platforms still do not fully meet the needs of students with special needs. This situation indicates that the principles of Universal Design for Learning (UDL) have not yet been fully

individual's interaction with the social environment in which they learn. Virtual environments provide a new space that allows students to experiment, take risks, and learn from mistakes without facing the social pressures often present in traditional classrooms. These conditions create a psychological experience that supports the development of self-confidence and academic competence.

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From the perspective of social identity theory, academic identity is formed through an integrated into the design of educational technology. In fact, UDL emphasizes the importance of providing diverse forms of representation, engagement, and expression in learning so that all students can have an equitable learning experience.

These findings align with the study “ , which highlights various accessibility barriers in the implementation of immersive technologies. However, this study provides an additional perspective by demonstrating how these barriers are directly experienced by students in their daily academic lives. Thus, this study demonstrates that the success of digital transformation depends heavily on the extent to which technology is designed based on principles of inclusivity and social justice.

Theoretical Contributions of the Research

This study makes an important contribution to the literature on learner agency, adaptive learning, immersive technology, and inclusive higher education. The findings indicate that learner agency is a construct shaped by the dynamic interaction between individual characteristics, technology design, learning experiences, and the social context in which learning takes place.

Unlike most previous studies, which view learner agency as an individual attribute, this study demonstrates that agency is a relational phenomenon that develops through students' experiences in adaptive and immersive learning environments. Therefore, learner agency should be understood as the result of multidimensional interactions among people, technology, and the educational context.

This study also suggests that the relationship between adaptive learning, immersive technology, and inclusive education is mutually reinforcing. Personalized learning enhances students' control over their learning, immersive experiences strengthen engagement and academic identity, while an inclusive environment provides conditions that foster participation and empowerment. The interaction of these three components forms the foundation for the development of learner agency in the era of digital transformation in higher education.

Practical Implications and Future Research Agenda

In practical terms, the research findings indicate that higher education institutions need to view digital transformation as a pedagogical and social process, not merely a

technology project. The implementation of immersive technologies and adaptive learning must be accompanied by faculty capacity-building strategies, adequate technical support, and accessibility policies that ensure the participation of all students.

Educational institutions also need to integrate the principles of Universal Design for Learning into the development of digital platforms so that the technology used can accommodate the diverse needs of students. Additionally, the development of educational technology should consider aspects of psychological well-being, a sense of safety, and user experience as integral parts of learning design.

This study has limitations because it was conducted within the context of specific institutions and participants; therefore, the findings are not intended to be statistically generalized. Nevertheless, this study provides an in-depth understanding of students' experiences that can serve as a foundation for the development of more inclusive theories and practices in digital higher education.

Future research could expand the scope of the study to include various types of higher education institutions, involve a more diverse group of students, and employ a longitudinal design to understand the development of learner agency over time. A combination of qualitative and quantitative approaches is also necessary to gain a more comprehensive understanding of the relationship between the “ ” of immersive technology, adaptive learning, inclusive education, and the transformation of students' learning experiences.

CONCLUSION

This study demonstrates that adaptive learning based on immersive technology in the context of inclusive higher education serves not only as a digital medium for delivering learning materials, but also as an ecosystem that shapes the learning experience, learner agency, and students' academic participation. The research findings identify four main themes: the transformation of the learning experience from access to meaningful participation; personalized learning as the foundation of learner autonomy; immersive technology as a space for the reconstruction of academic identity; and the challenges of inclusivity within the digital learning ecosystem. The research results indicate that adaptive and immersive learning experiences enable students to engage more actively in the process of knowledge construction, develop the ability to manage their learning independently, and build stronger self-confidence and academic identity. At the same time, this study emphasizes that digital transformation still faces challenges related to accessibility, infrastructure readiness, and equity in learning opportunities that require attention in the development of digital higher education.

Theoretically, this study enriches the literature on learner agency by demonstrating that learner autonomy is the result of a dynamic interaction between individual characteristics, learning experiences, technology design, and the context of inclusive education. These findings expand our understanding of the relationship between adaptive learning, immersive technology, and inclusive education, which has previously been studied primarily from the perspective of technological effectiveness. Practically, the research results have implications for higher education institutions to develop digital

transformation policies that are not only oriented toward technological innovation but also consider pedagogical aspects, accessibility, and the diversity of student needs. From a policy perspective, educational institutions must ensure that the implementation of digital technology is grounded in the principles of inclusivity, equity, and user empowerment so that all students can gain meaningful learning experiences. Future research is recommended to involve a more diverse range of institutional contexts, employ a longitudinal approach, and combine qualitative and quantitative methods to gain a more comprehensive understanding of the development of learner agency within the evolving digital learning environment.

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