Teaching in the Immersive Era: Professors' Perspectives on XR in Higher Education

Rafaela Otemaier
Graduate Program in Computer Science (PPGIa), Pontifícia Universidade Católica do Paraná (PUCPR)
Curitiba, Paraná, Brazil
kelly.rafaela@pucpr.br

Regina Albuquerque
Polytechnic School, Pontifícia Universidade Católica do Paraná (PUCPR)
Curitiba, Paraná, Brazil
regina.fabia@pucpr.br

Ericson Savio Falabretti
Graduate Program in Philosophy (PPGF), Pontifícia Universidade Católica do Paraná (PUCPR)
Curitiba, Paraná, Brazil
ericson.falabretti@pucpr.br

Sheila Reinehr
Graduate Program in Computer Science (PPGIa), Pontifícia Universidade Católica do Paraná (PUCPR)
Curitiba, Paraná, Brazil
sheila.reinehr@pucpr.br

Andreia Malucelli
Graduate Program in Computer Science (PPGIa), Pontifícia Universidade Católica do Paraná (PUCPR)
Curitiba, Paraná, Brazil
andreia.malucelli@pucpr.br

Abstract

The increasing presence of digital natives in higher education has intensified the demand for innovative teaching methodologies that enhance student engagement and learning outcomes. In this context, Extended Reality (XR), encompassing Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), has gained traction as a means to create immersive environments that support experiential learning. This study aims to analyze professors' perceptions regarding the adoption, benefits and challenges of immersive technologies in higher education. A survey was conducted with 40 professors who have recently started using these technologies in their classes. The results reveal that immersive environments enhance student engagement, comprehension, and interaction. However, challenges such as limited infrastructure, insufficient technical knowledge, and content adaptation were identified as barriers to adoption. Despite these challenges, 94.1% of respondents expressed their intention to continue using immersive technologies. The findings suggest that addressing these obstacles through targeted support and training could improve the integration of XR tools, thereby increasing their effectiveness for educational purposes.

Keywords

Immersive learning, Immersive learning technology, Extended reality, Higher education

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1 Introduction

The evolution of student profiles with the rise of digital natives demands more interactive and technology-enhanced pedagogical strategies. Studies indicate that a significant challenge in higher education is promoting student engagement, especially in practical activities, due to a lack of methodologies that effectively bridge innovation and industry needs [3, 9, 16]. A key challenge in this domain is designing learning experiences that capture students' interest and enhance knowledge retention and skill acquisition [10, 15].

In this context, Extended Reality (XR), encompassing Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), has gained traction as a means to create immersive environments that support experiential learning. Prior studies [1, 8] highlight that XR enables controlled, interactive, and scalable simulations of real-world tasks, promoting active learning through dynamic content interaction. Despite the potential of XR in education, several barriers hinder widespread adoption. Challenges include the scarcity of domain-specific learning content, limited institutional infrastructure, and insufficient faculty training to design and implement immersive pedagogical experiences [11]. Additionally, integrating XR into existing curricula requires interdisciplinary collaboration and technical expertise, posing further adoption constraints.

Recent surveys have shown that higher education institutions worldwide increasingly invest in immersive technologies to meet the evolving demands of Generation Z learners, who expect dynamic and hands-on pedagogical experiences [2, 5]. Scholars argue that XR fosters deeper levels of cognitive and affective engagement, aligning with constructivist approaches that emphasize active learning [19]. Despite these prospects, empirical evidence on how professors perceive, adopt, and scale these tools remains limited, particularly in developing countries. This study, therefore, seeks to fill this gap, shedding light on both the potential and the challenges that come with XR in higher education.

To address these challenges, the Pontifical Catholic University of Paraná (PUCPR) launched the Extended Reality Center (CRE) in 2023, comprising two dedicated facilities. The PUCPR Digital Arena includes a 4D theater with a 14-meter-diameter dome and an immersive plaza with a 12 × 2.5-meter curved screen. Spanning 3,000 m^2, the CRE also houses 18 specialized environments, such as a CAVE for collective XR experiences, a virtual production studio for film and game development, a 3D printing lab for rapid prototyping, and discipline-specific rooms equipped with VR, MR, and AR devices. These environments are supported by a dedicated technical team, fostering research and pedagogical applications of XR across multiple disciplines.

Since its inception, professors have leveraged the CRE to incorporate XR-based learning objects into their courses, using pre-existing materials or designing custom interactive content. This study aims to analyze professors' perceptions regarding the adoption, benefits, and challenges of immersive technologies in higher education.

The remainder of this paper is organized as follows: Section 2 reviews the literature on immersive learning environments, Section 3 describes the research methodology, Section 4 presents the results, Section 5 discusses the findings, and Section 6 offers concluding remarks

2 Immersive Learning Environments

Immersion is the "mental state in which the user is deeply engaged in an immersive environment" [17]. Immersive learning environments are educational settings that utilize technologies such as VR, AR, and MR to provide interactive and engaging experiences. These environments simulate the real world, allowing students to explore, interact, and learn more effectively and compellingly [14]. Additionally, they offer a safe and controlled space for practical experiences and can be applied in various contexts, including classrooms, virtual laboratories, professional training, and simulations.

According to Suh and Prophet [18], users' reactions in immersive environments are associated with elements such as immersion, presence, flow, illusion, situated cognition, and the sense of body ownership about the virtual world. These authors distinguish between mental immersion, which corresponds to the cognitive sensation of being deeply engaged, and physical immersion, which combines sensory and cognitive stimuli to create a fully immersive experience. Physical immersion is achieved through the interpretation of visual, auditory, and tactile stimuli, allowing users to navigate and interact with objects in a synthetic environment. Such elements enhance the realism and engagement of the virtual experience.

Moreover, Suh and Prophet [18] emphasize that immersive technology can be understood from different perspectives. While some researchers focus on sensory information as its primary characteristic, they emphasize the user's immersion experience, essential for enhancing virtual simulations' realism.

This concept encompasses technologies such as VR, AR, and MR. AR integrates virtual elements with the real world, while VR creates an entirely virtual environment where users can interact and navigate. Both contribute to different levels of MR, which merges physical and virtual objects into a single space, providing a rich and dynamic immersive experience.

AR, in particular, superimposes virtual objects onto the real environment in real-time, using three-dimensional (3D) registration. This approach enhances visual, auditory, and tactile senses by overlaying digital information onto the physical world. On the other hand, VR creates interactive virtual environments to simulate real-world experiences. Immersive VR stands out for employing advanced devices, such as head-mounted displays (HMDs), which track user movements and adjust images in real-time, offering a higher level of immersion by isolating external stimuli. These systems can also collect data on user behavior and responses, providing valuable insights for future technology development. A notable example of immersive VR is CAVE (Cave Automatic Virtual Environment), a virtual environment that delivers an immersive experience through large-scale projections.

Given these advancements, immersive learning emerges as a promising educational approach. This approach, despite its various definitions [7], effectively bridges the gap between academic learning and market demands by offering practical, hands-on experiences. By integrating innovative methods and technologies [14], immersive learning not only enhances student engagement but also prepares them more effectively for real-world challenges.

3 Related Work

Several studies have explored the adoption of immersive technologies in higher education, focusing on faculty perceptions, institutional challenges, and pedagogical integration strategies. This section reviews relevant works and highlights how the present study differs by investigating faculty members who are already actively using XR technologies within an institutional context equipped with dedicated infrastructure.

Meccawy [13] examined the prospective attitudes of ten educators in Saudi Arabia, working in both public and private institutions at the K-12 and higher education levels, regarding adopting XR technologies. The study identified factors such as teacher awareness, content creation, institutional readiness, and sociocultural challenges, particularly in conservative contexts. In contrast, our research was conducted in Brazil and focuses on faculty already implementing XR, thus providing empirical evidence of practical experiences within a structured university environment rather than hypothetical perceptions or expectations.

Carpenter et al. [6] conducted a survey involving 189 higher education faculty members in the United States concerning adopting Virtual Reality (VR). They emphasized challenges such as cost, technical support, content availability, and teacher training. While we share a similar survey-based methodological approach and focus on higher education, our study diverges by addressing Extended Reality (XR) more broadly—including Augmented Reality (AR) and Mixed Reality (MR) and by examining its implementation within a single institution housing a specialized XR center (CRE), which enables a deeper understanding of institutional support mechanisms.

McGrath, Hoffman, and Dark [12] discuss the adoption of AR and VR at UC Berkeley from a strategic and institutional perspective, highlighting policy-level challenges such as accessibility, privacy, safety regulations, and the development of high-quality educational content. Whereas their analysis is centered on governance and academic technology infrastructure, our study provides an operational perspective grounded in instructors' experiences as key users of immersive technologies in the classroom. This complementary approach facilitates the connection between institutional decisions and practical teaching realities.

Bawa and Bawa [4] employed a phenomenographic methodology to explore the perceptions of three university faculty members from fields such as Instructional Design and the Humanities regarding the use of VR. Their study revealed high interest levels but also technical barriers such as device discomfort and content limitations. Compared to this qualitative, small-sample study, our research applies a structured survey with 40 faculty members from various disciplines, offering a more generalizable perspective focused on practical experience with XR—not solely VR.

Together, these studies provide necessary theoretical and empirical foundations for understanding the adoption of immersive technologies in education. However, our study makes an original contribution by examining a diverse group of faculty already using XR in higher education within a Brazilian university that has invested in a dedicated immersive center. This allows us to advance the understanding of perceived benefits, experienced challenges, and institutional conditions that foster the effective use of XR in teaching practice.

4 Research Method

This study employed a survey research method to investigate professors' perceptions of immersive technologies in higher education. The method was divided into the following steps:

- **Development of the questionnaire**: A questionnaire was designed with 23 questions, including 10 closed-ended and 13 open-ended items. The questions aimed to understand how professors perceive and utilize immersive technologies in their teaching practices.
- **Pilot test**: To evaluate the clarity, structure, and estimated response time, a pilot test was conducted with two professors. Based on the feedback received, adjustments were made to improve the questionnaire, ensuring greater response accuracy.
- **Survey distribution**: The final version of the questionnaire was sent via email to a group of 50 professors from PUCPR, all of whom had prior experience using immersive technologies in teaching.
- **Data collection**: A total of 40 valid responses were collected. The data obtained were used for analysis, focusing on professors' perceptions of the adoption, benefits, and challenges of immersive technologies in higher education.
- **Data analysis**: Closed-ended Questions: These were analyzed using descriptive statistics to provide a quantitative overview of the responses. Open-ended Questions: The open-ended responses were analyzed using qualitative content analysis, allowing for a deeper understanding of participants' insights and experiences.

5 Results

5.1 Participant Profile and Adoption of Immersive Technologies

The respondent pool (N = 40) comprised faculty members from a range of academic backgrounds, with Health Sciences (29.4%), Engineering (20.6%), and Exact and Earth Sciences (17.6%) representing the largest subgroups. This disciplinary diversity underscores the broad interest in immersive technologies across distinct domains.

In particular, a substantial share (79.4%) reported over a decade of teaching experience, indicative of experienced professionals who appear motivated to explore or refine technology-driven pedagogical strategies.

Regarding the nature of immersive technology usage, 85% of respondents had employed at least one type of immersive modality in their instruction, primarily VR headsets and interactive 3D simulators. Of this contingent, a plurality (50%) predominantly used existing commercial or open-source solutions, while the remainder combined or developed specialized resources for specific pedagogical aims. Notably, this distribution points to a continuum of technical independence: some faculty leverage vendor-provided materials, whereas others engage in content creation and customization, signaling varying degrees of technical proficiency and institutional support.

5.2 Frequency of Use and Student Reach

Although the integration of immersive tools was widespread among participating professors, its frequency varied markedly. Half of those integrating immersive content (50%) reported between two and five distinct implementations, whereas 38.2% restricted themselves to a single intervention, often citing constraints in time, technical training, or infrastructure. A smaller fraction (11.8%) indicated more than five immersive sessions, suggesting that some educators are pivoting toward systematically embedding immersion into their teaching models.

Such usage patterns directly translated to differential student exposure. While 41% of respondents estimated that 50–100 students had benefited from immersive learning activities, 26% indicated fewer than 50 students, and 18% reported engaging between 101 and 200 students. Notably, approximately 15% of respondents reached over 200 students, highlighting the potential scalability for large-course adoption.

As institutional support grows, these figures may shift, allowing immersive methods to impact a broader segment of the student body across multiple disciplines and academic terms.

5.3 Perceived Benefits

A predominant theme emerging from the qualitative and quantitative data was the marked elevation of student engagement. This conclusion is supported by 44.1% of participants who rated engagement levels as "high" and 35.4% who deemed them "very high" when comparing immersive sessions against traditional lectures. Meanwhile, 17.6% considered engagement "moderate," and only 2.9% rated it as "low."

Moreover, the overwhelming consensus positioned immersive technologies as either "superior" (52.9%) or "much superior" (23.5%)

relative to conventional techniques for capturing student attention and fostering active learning, while 20.7% found them "equal" and a minimal 2.9% perceived them as "inferior."

Open-ended responses highlight that immersive tools bolster experiential learning, allowing students to absorb theoretical concepts and practice skills in simulated real-world contexts. This hands-on dimension, coupled with higher interactivity, was repeatedly cited as a catalyst for deepened comprehension and motivational gains.

Additionally, the capacity to tailor interactions and promptly visualize complex data or processes was instrumental in enhancing the educational experience, especially in fields requiring visual-spatial understanding.

5.4 Main Challenges

Despite these reported advantages, several obstacles temper the prospects for seamless adoption. Infrastructure deficits—namely insufficient hardware, inadequate facilities, and limited technical support—were the most frequently mentioned barrier (47.5%). This shortfall constrains the number of simultaneous users and can undermine the smoothness and reliability of immersive experiences, especially for large classes.

Professors also noted the challenge of developing familiarity with specialized software and devices (27.5%). While many demonstrated enthusiasm for experimenting with novel approaches, they also reported a steep learning curve in mastering new platforms, adapting content to fit immersive formats, and troubleshooting technical issues in real-time.

Some respondents specifically mentioned the imbalance between intensive preparation demands and university expectations, highlighting the need for institutional policies and training that accommodate the additional workload.

Lastly, some educators encountered initial student reluctance stemming from unfamiliarity or motion-sickness issues, though such resistance typically decreased as learners grew more accustomed to the technology.

6 Discussion

This section analyzes the study's main findings. Although there is a consensus regarding the benefits of learning, challenges remain that hinder large-scale adoption, indicating the need for specific policies and strategies to expand its use.

Active engagement and participation: Immersive technologies (VR, AR, and MR) were recognized by most faculty members as practical tools to increase student interest and motivation, mainly due to the possibility of experiencing simulated and manipulable scenarios, thereby bridging theory and practice.

Perceived Benefits: Overall, participants reported improvements in content understanding, student engagement, and information retention. Safe simulations, immediate feedback, and the sensation of presence in realistic situations were key to enhancing learning. However, broader adoption still demands adequate infrastructure and efficient technical support.

Faculty Training and Institutional Support: Providing training programs, workshops, and technical assistance is crucial for enabling instructors to design relevant content and effectively use devices. In this regard, insufficient equipment and a lack of support staff can discourage frequent classroom application.

Curricular Integration and Incentive Policies: Despite initial enthusiasm, integrating VR/AR/MR into curricula requires pedagogical planning and policies that address resources, preparation time, and partnerships for developing specialized materials. Institutional incentives are fundamental in establishing immersive technologies as mainstream teaching tools.

Limitations: The sample in this study was limited to a single institution, which may constrain the generalizability of the findings.

7 Conclusion

This research analyzed professors' perceptions regarding immersive technologies' adoption, benefits, and challenges in higher education. Forty professors who have recently started using these technologies in their classes at PUCPR were surveyed.

The results highlight a positive impact on student interaction, engagement, and comprehension. Nonetheless, challenges such as limited infrastructure, insufficient faculty training, and difficulties adapting content remain significant barriers to broader adoption. Despite these challenges, most professors intend to continue using these tools, reinforcing their transformative educational potential.

Institutional policies should be implemented to maximize the impact of immersive technologies. These policies should ensure continuous technical support, specialized training programs, and strategies for curriculum adaptation. Even so, the results underscore the innovative potential of immersive technologies and pave the way for future research in diverse contexts.

Future studies will expand the sample to include professors from various institutions and disciplines. Additionally, further research could explore the long-term effects of immersive technologies on student learning outcomes and investigate how various faculty development programs influence the successful integration of these technologies into teaching.

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