Virtual Reality and Augmented Reality in Teacher Training: Redefining Pedagogical Practices in Higher Education

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***Abstract* — This paper reports an exploratory mixed-methods case study of a single three-hour training session, developed within the Erasmus+ project "The Power of AR & VR", with 26 Master's students in Computer Science Teaching at the University of Minho. The session was designed to introduce Virtual Reality (VR) and Augmented Reality (AR) for Higher Education from a constructivist standpoint, integrating the CLASSVR platform, the ARloopa application, and the browser-based Delightex Edu environment. Adopting a convergent mixed-methods design, we combined a pre- and post-session questionnaire (a 12-item Likert instrument plus self-report items) with structured non-participant observation and analysis of the artefacts that participants produced during a guided build task. Quantitative results indicate a statistically detectable shift in self-reported confidence to integrate immersive technologies (median pre = 2.0, post = 4.0 on a 5-point scale; Wilcoxon signed-rank test, n = 24), alongside high post-session ratings for perceived pedagogical usefulness. Qualitative evidence converged on three themes: engagement, pedagogical intentionality, and the value of the learner-as-creator stance. Because the intervention was a one-off, short session with a small, single-cohort sample, the findings are framed as exploratory and as evidence of immediate, perceived value rather than of sustained behavioural change. We therefore foreground a longitudinal research agenda to test transfer to practice. The study contributes to the literature on immersive technologies in teacher education by articulating technological literacy with critical pedagogical reflection.**

***Keywords* - virtual reality; augmented reality; teacher training; higher education; immersive technologies; mixed methods; pedagogical innovation**

I. Introduction

The integration of immersive technologies into teaching and learning has become one of the most widely discussed vectors of pedagogical innovation in the twenty-first century. Virtual Reality (VR) and Augmented Reality (AR) are frequently positioned as tools with the potential to reshape classroom dynamics, particularly in Higher Education, where student engagement and deep learning remain persistent challenges [1], [2].

In teacher education the issue is especially pressing. Prospective teachers must master disciplinary content and pedagogical method, but they also need to develop digital-literacy competencies and a critical disposition towards the technologies they adopt [3]. Preparing teachers to use immersive tools pedagogically therefore requires a formative process that goes beyond technical demonstration and engages participants in reflection on the design of meaningful learning experiences [4].

This paper describes and analyses a single three-hour training session conducted with 26 students from the Master's in Computer Science Teaching at the University of Minho, aimed at introducing VR and AR for Higher Education. The study is framed explicitly as an exploratory, convergent mixed-methods case study [20], [21]: a brief quantitative strand (pre–post self-report) is integrated with a qualitative strand (structured observation and artefact analysis) to characterise immediate, perceived value rather than to establish causal or long-term effects. The session was designed on constructivist and experiential principles [5], prioritising active participation and reflection on pedagogical intentionality.

The study is situated within the broader problem of redefining pedagogical practices in Higher Education through digital innovation, and addresses two research questions: (i) In what ways does a short, hands-on exposure to immersive technologies influence trainee teachers' perceptions of the pedagogical potential of VR and AR? (ii) Which pedagogical dimensions emerge as most salient when these teachers consider curricular integration? Consistent with the exploratory design, we treat the findings as hypothesis-generating rather than confirmatory.

II. Literature Review

A. Immersive Technologies and Meaningful Learning

Meaningful learning, as conceptualised by Ausubel [6], presupposes the non-arbitrary integration of new knowledge into existing cognitive structures. By providing situated, contextualised experiences, immersive technologies can create favourable conditions for this kind of learning [7]. Evidence suggests that VR, by simulating environments that would be unfeasible or impossible to access physically, can support the comprehension of abstract concepts and deeper cognitive engagement [8]. AR, by superimposing digital elements onto the physical world through smartphones, tablets, or smart glasses [9], has been associated with increased motivation and interest and with improved comprehension of complex content [10].

It should be noted, however, that much of the foundational evidence predates the current generation of devices. More recent systematic and meta-analytic reviews of extended reality (XR) in education and, specifically, in teacher education [2], [14], [22], [23] temper earlier optimism: they report heterogeneous effect sizes, a recurring "novelty effect", and a shortage of studies that measure transfer to classroom practice.

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These reviews motivate the cautious, exploratory stance adopted here.

B. Teacher Training and Digital Literacy

Effective integration of immersive technologies demands more than technical competence. Mishra and Koehler [11] proposed the TPACK framework, which stresses the articulation of technological, pedagogical, and content knowledge, and which has become a standard reference for teacher training in digital-innovation contexts [12]. Research indicates that teachers integrate technologies more effectively when training is experiential, reflective, and embedded in concrete professional practice [13]; mere exposure to tools, without a pedagogical frame, is insufficient to produce lasting change [14].

C. Virtual and Augmented Reality in Higher Education

In Higher Education, several studies report pedagogical benefits from immersive technologies. Freina and Ott [15] noted associations with active engagement and collaborative learning, and VR simulation has shown promising results when preparing students for clinical procedures [16]. More recent reviews [2], [22] confirm growing adoption while cautioning that methodological quality remains uneven. Browser-based immersive environments, such as FrameVR.io or Delightex Edu, combine features of the educational metaverse with explicit pedagogical purposes, enabling collaborative, gamified activities accessible from any connected device [17].

The literature also highlights the "learning-by-doing" approach, associated with Papert's constructionism [18], as a productive frame for integrating AR and VR. When students are invited to create immersive learning objects, rather than to consume them passively, learning can become richer and more oriented towards knowledge construction [19].

III. Materials and Methods

A. Research Design

We adopted an exploratory convergent parallel mixed-methods case-study design [20], [21]. A quantitative strand (a pre–post questionnaire) and a qualitative strand (structured non-participant observation and artefact analysis) were collected concurrently and integrated at the interpretation stage. The design is exploratory by intent: a single, short session cannot support causal inference, so the quantitative strand is used descriptively, to triangulate and partially corroborate the qualitative findings, not to estimate effects.

B. Context and Participants

The session took place within the Master's in Computer Science Teaching at the University of Minho, Portugal, and involved 26 postgraduate students-prospective secondary-school computer-science teachers. Twenty-four of the 26 completed both the pre- and post-session questionnaires (two were absent for part of the session and are excluded from the paired analysis). The session lasted approximately three hours and was designed and facilitated by the researcher, a specialist in Educational Technology affiliated with Instituto Piaget.

C. Session Structure, Objectives, and Tasks

To support replicability, Table I sets out the timetable, the learning objective of each phase, and the concrete tasks undertaken. The design privileged experiential learning and critical reflection, guided by three principles: (a) constructivism, participants actively explored the tools and built a small artefact; (b) pedagogical intentionality, every exploration was tied to reflection on why and how to integrate the technology; and (c) design thinking - trainees sketched an immersive activity for their own future students.

TABLE I. Session Timetable, Objectives, and Tasks

Phase (min)	Objective	Concrete task
1. Framing (40′)	Build shared conceptual vocabulary for VR/AR and immersive web.	Facilitator-led overview; participants mapped tools to disciplinary use cases.
2. Hands-on (90′)	Experience and operate the three platforms.	Guided exploration of CLASSVR; AR triggers via ARloopa; building a 3-zone scene in Delightex Edu.
3. Create (30′)	Apply the learner-as-creator stance.	In pairs, draft and assemble a minimal immersive activity for a chosen topic.
4. Reflection (20′)	Reflect on pedagogical intentionality and integration.	Structured group discussion against four prompts; completion of post-session questionnaire.

D. Tools, Hardware, and Access

Three tools were selected for accessibility, ease of classroom use, and documented relevance: the CLASSVR platform (a managed headset system whose teacher console synchronises learners' views); ARloopa (for pre-configured AR content on participants' own smartphones); and Delightex Edu (browser-based 3D authoring requiring no specialist hardware). Regarding access and equity: the venue provided a class set of eight CLASSVR headsets, so headset activity was organised in rotating groups of three to four; AR and Delightex tasks ran on participants' own laptops and smartphones over institutional Wi-Fi. All participants therefore had hands-on headset time, although not simultaneously - a constraint typical of school deployments and acknowledged in the limitations.

E. Data Collection

Two complementary sources were used. First, a questionnaire administered immediately before and after the session comprised twelve 5-point Likert items (1 = strongly disagree, 5 = strongly agree) covering self-reported confidence, perceived usefulness, and intention to integrate, plus two open-response items. Second, structured non-participant observation was conducted using an a-priori schedule with five categories (active participation, spontaneous questioning, on-task collaboration, help-seeking, and off-task behaviour). The facilitator-researcher recorded time-stamped field notes against these categories at fixed five-minute intervals, supplemented by photographs of the activity (Fig. 1) and by collection of the artefacts produced in Phase 3. The artefacts were later scored with a simple three-criterion rubric (pedagogical alignment, interactivity, and clarity of navigation), each rated 0-2.

Quantitative data were analysed with descriptive statistics; because the Likert responses are ordinal and the sample is

small, paired pre–post comparisons used the Wilcoxon signed-rank test, with the result read as indicative rather than definitive. Qualitative data (open responses, field notes, and rubric-scored artefacts) were analysed thematically and then compared with the quantitative pattern in a joint display.



Fig. 1. Engagement among participants.

F. Ethics

The study respected the ethical principles applicable to research with human participants. Participation was voluntary, data were anonymised and treated confidentially, and participants were informed of the objectives and gave informed consent.

IV. Results and Discussion

A. Quantitative Findings

Of the 26 participants, 24 provided paired responses. Self-reported confidence to integrate immersive technologies rose from a pre-session median of 2.0 (IQR 2-3) to a post-session median of 4.0 (IQR 3-4); the Wilcoxon signed-rank test indicated this shift was unlikely to be due to chance ($p < 0.01$), though with an observational, single-session design we interpret it as a change in perception rather than evidence of capability. Perceived pedagogical usefulness was high after the session (median 4.0), as was stated intention to explore the tools further (median 4.0). Table II summarises the three composite indicators.

TABLE II. Pre–Post Self-Report (5-point scale, N = 24)

Indicator	Pre (Mdn)	Post (Mdn)
Confidence to integrate VR/AR	2.0	4.0
Perceived pedagogical usefulness	3.0	4.0
Intention to explore further	3.0	4.0

These figures should be read with caution. The instrument captures self-report, not demonstrated competence; the gain is consistent with, but cannot be separated from, a novelty effect; and the absence of a comparison group precludes causal claims.

B. Engagement and Motivation

Observation corroborated the survey pattern. Across the fixed five-minute sampling points, active participation and on-task collaboration were recorded at the great majority of intervals, with frequent spontaneous questioning during the hands-on phase (Fig. 1). CLASSVR attracted particular interest, less for novelty than for its teacher console, which several participants identified as pedagogically significant because it supports the management of attention and pace. We note, however, that engagement and motivation do not by themselves entail improved learning outcomes; given a single session with a small cohort, these indicators are best read as immediate responses rather than durable effects [1], [8], [14].

C. Artefacts and the Learner-as-Creator Stance

During Phase 3, the twelve pairs each produced a minimal immersive activity in Delightex Edu. On the three-criterion rubric (max 6), artefacts scored a median of 4, with pedagogical alignment generally stronger than navigational clarity, several scenes were conceptually sound but visually cluttered. These outputs are modest, first-attempt prototypes; we therefore treat the learner-as-creator stance as a promising design principle evidenced by genuine, if preliminary, artefacts, rather than as a fully demonstrated competence. The rubric and anonymised artefacts are available from the author.

D. Reflection on Pedagogical Intentionality

A salient qualitative outcome was the quality of participants' reflection on pedagogical intentionality. Rather than valuing the tool in itself, trainees interrogated the conditions under which VR and AR add pedagogical value, recurrently identifying: (i) alignment with curricular objectives; (ii) activities that promote active participation rather than passive observation; (iii) articulation with other strategies; and (iv) access and equity. These themes are consistent with TPACK [11] and with work that foregrounds pedagogical design in technology integration [4].

E. Perceived Transformative Potential

Participants saw particular promise in VR's capacity to create "impossible journeys" (into the human body, to remote periods, or to otherwise inaccessible environments) for disciplines that benefit from visualisation and simulation. They also valued the prospect of students becoming creators of immersive content. Browser-based environments were recognised as spaces for collaborative remote activity that preserve a sense of shared presence without physical co-presence, which is pertinent to distance and hybrid teaching [17]. We present these as perceived potentials reported by participants, not as measured outcomes.

F. Identified Challenges

Participants identified practical barriers to future integration: infrastructural limits and uneven device access in schools; the need for ongoing technical training; the difficulty of fitting immersive activities into densely structured curricula; and ethical questions around pupils' data and appropriate boundaries of use. These are well documented [3], [14] and indicate that adoption requires not only equipment and training but also systemic change in policy and institutional culture.

V. Limitations

Several limitations bound the claims of this study, and we state them explicitly. First, the intervention was a single three-hour session: such a format can raise awareness and confidence but cannot, on its own, evidence sustained change or transfer to classroom practice. Second, the observed gains are vulnerable to a novelty effect, which is well documented for immersive media and which short, one-off exposures are least able to control for. Third, the sample is small (n = 26; 24 paired), drawn from a single cohort and discipline, and was assessed without a comparison group, so the design is observational and the quantitative results are descriptive rather than confirmatory. Fourth, the key learning indicators are self-reported; the artefact rubric provides only a coarse, first-attempt measure of design quality. Accordingly, all conclusions are framed as exploratory and hypothesis-generating.

VI. Conclusion

This exploratory mixed-methods study suggests that teacher training focused on the pedagogical exploration of immersive technologies, when designed to be reflective, experiential, and centred on pedagogical intentionality, can be associated with high immediate engagement, a marked rise in self-reported confidence, and the production of preliminary immersive artefacts. We deliberately refrain from stronger causal or long-term claims: with a single short session and a small single-cohort sample, the evidence speaks to immediate, perceived value rather than to durable competence or changed practice.

The 26 trainee teachers showed interest in the tools and, more importantly, a developing capacity to situate them within grounded pedagogical frameworks. The "learning-by-doing" approach associated with constructivism again appears to offer a useful reference for professional development in digital-innovation contexts.

The principal implication is methodological. To establish whether sessions of this kind have lasting value, future work should (i) use longitudinal, multi-session designs with delayed follow-up; (ii) include comparison or waitlist groups to isolate the novelty effect; (iii) measure transfer through observed classroom practice and validated competence rubrics rather than self-report; and (iv) link these practices to Higher Education students' learning outcomes. The systematic, longitudinal evaluation of immersive-technology training thus remains a relevant and urgent agenda.

Conflict of Interest

The author declares no conflict of interest.

Author Contributions

Celestino Magalhães conceived and implemented the training session, designed the instruments, collected and analysed the data, and authored this paper.

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References

[1] S. Freeman, S. L. Eddy, M. McDonough, M. K. Smith, N. Okoroafor, H. Jordt, and M. P. Wenderoth, "Active learning increases student performance in science, engineering, and mathematics," Proc. Natl. Acad. Sci., vol. 111, no. 23, pp. 8410-8415, 2014.

[2] J. Radianti, T. A. Majchrzak, J. Fromm, and I. Wohlgenannt, "A systematic review of immersive virtual reality applications for higher education," Comput. Educ., vol. 147, art. 103778, 2020.

[3] J. Tondeur, J. van Braak, P. A. Ertmer, and A. Ottenbreit-Leftwich, "Understanding the relationship between teachers' pedagogical beliefs and technology use," Educ. Technol. Res. Dev., vol. 65, no. 3, pp. 555-575, 2017.

[4] M. Bower, C. Howe, N. McCredie, A. Robinson, and D. Grover, "Augmented Reality in education - cases, places and potentials," Educ. Media Int., vol. 51, no. 1, pp. 1-15, 2014.

[5] D. A. Kolb, Experiential Learning: Experience as the Source of Learning and Development. FT Press, 2014.

[6] D. P. Ausubel, The Psychology of Meaningful Verbal Learning. New York: Grune & Stratton, 1963.

[7] Z. Merchant, E. T. Goetz, L. Cifuentes, W. Keeney-Kennicutt, and T. J. Davis, "Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis," Comput. Educ., vol. 70, pp. 29-40, 2014.

[8] L. Jensen and F. Konradsen, "A review of the use of virtual reality head-mounted displays in education and training," Educ. Inf. Technol., vol. 23, no. 4, pp. 1515-1529, 2018.

[9] R. T. Azuma, "A survey of augmented reality," Presence: Teleoperators Virtual Environ., vol. 6, no. 4, pp. 355-385, 1997.

[10] H. K. Wu, S. W. Y. Lee, H. Y. Chang, and J. C. Liang, "Current status, opportunities and challenges of augmented reality in education," Comput. Educ., vol. 62, pp. 41-49, 2013.

[11] P. Mishra and M. J. Koehler, "Technological pedagogical content knowledge: A framework for teacher knowledge," Teachers College Record, vol. 108, no. 6, pp. 1017-1054, 2006.

[12] J. Voogt, P. Fisser, N. Pareja Roblin, J. Tondeur, and J. van Braak, "Technological pedagogical content knowledge - a review of the literature," J. Comput. Assist. Learn., vol. 29, no. 2, pp. 109-121, 2013.

[13] P. A. Ertmer and A. T. Ottenbreit-Leftwich, "Teacher technology change: How knowledge, confidence, beliefs, and culture intersect," J. Res. Technol. Educ., vol. 42, no. 3, pp. 255-284, 2010.

[14] N. Pellas, P. Fotaris, I. Kazanidis, and D. Wells, "Augmenting the learning experience in primary and secondary school education: A systematic review of recent trends in augmented reality game-based learning," Virtual Reality, vol. 23, no. 4, pp. 329-346, 2019.

[15] L. Freina and M. Ott, "A literature review on immersive virtual reality in education: state of the art and perspectives," in Proc. eLearning and Software for Education (eLSE), vol. 1, pp. 133-141, 2015.

[16] J. Pottle, "Virtual reality and the transformation of medical education," Future Healthc. J., vol. 6, no. 3, pp. 181-185, 2019.

[17] S. Mystakidis, "Metaverse," Encyclopedia, vol. 2, no. 1, pp. 486-497, 2022.

[18] S. Papert, Mindstorms: Children, Computers, and Powerful Ideas. New York: Basic Books, 1980.

[19] C. Dede, "Immersive interfaces for engagement and learning," Science, vol. 323, no. 5910, pp. 66-69, 2009.

[20] R. K. Yin, Case Study Research and Applications: Design and Methods, 6th ed. Thousand Oaks, CA: SAGE, 2018.

[21] J. W. Creswell and V. L. Plano Clark, Designing and Conducting Mixed Methods Research, 3rd ed. Thousand Oaks, CA: SAGE, 2018.

[22] D. Hamilton, J. McKechnie, E. Edgerton, and C. Wilson, "Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design," J. Comput. Educ., vol. 8, no. 1, pp. 1-32, 2021.

[23] M. Akçayır and G. Akçayır, “Advantages and challenges associated with augmented reality for education: A systematic review of the literature,” Educ. Res. Rev., vol. 20, pp. 1-11, 2017.

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