From Pilot to Practice: Towards an Ecosystem Model for Sustained Immersive Education

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Abstract. Immersive virtual reality (IVR) is more present in school contexts, with growing evidence of its pedagogical potential. Yet most implementations remain short-lived pilots, rarely transitioning into sustained institutional adoption. This paper sets forth from a paradox observed in a real school context, where a pilot project was successful: two teachers successfully integrated IVR into their classrooms at an international school in Lisbon, Portugal. That success revealed the real challenge: scaling from two teachers to many is not a technical problem, but an ecosystem coordination problem. Drawing on empirical findings from an action research study conducted at the school, and on gaps identified in the implementation literature, this paper argues that sustained IVR adoption requires an ecosystem model that maps the multiple actors involved, their interdependencies, and the conditions that enable their articulation. Time coordination, content appropriation and cultural readiness emerged as three interconnected challenges that no single actor can resolve alone. This paper contributes a preliminary ecosystem mapping of actors across pedagogical, leadership, support and external areas, and argues that further empirical research is needed to model their dynamic articulation as a condition for scaling immersive education beyond the pilot.

Keywords: Immersive Virtual Reality, Next-Generation Learning Platforms, Sustained Adoption, Educational Ecosystem, Multi-Actor Coordination, Digital Transformation in Education.

1 Introduction

Immersive virtual reality (IVR) is increasingly present in school contexts, with growing evidence of its pedagogical potential, particularly in STEM education (Ward et al., 2025). Yet, paradoxically, most implementations remain short-lived pilots, rarely transitioning into sustained institutional adoption (Hamilton et al., 2021; Zhan & Nasri, 2025).

This paper departs from an instance of this paradox, observed in a real school context: a pilot worked, with two teachers successfully integrating IVR into their classrooms at an international school in Lisbon, Portugal. And the paradox reported in the literature emerged: it was precisely that success that revealed the real challenge. Scaling from two teachers to many is not a technical problem, it is an ecosystem coordination problem.

Drawing on empirical findings from a master's dissertation (Sacavém, 2025) and the theoretical framework under development for an ongoing doctoral research project, this paper argues that sustained IVR adoption requires an ecosystem model that articulates the multiple actors involved: pedagogical, institutional, logistical, and external actors.

The urgency of this question is growing. As immersive technologies become more accessible and affordable, schools are increasingly encouraged to experiment with IVR, supported by enthusiastic suppliers, research pilots and policy initiatives. Yet the gap between experimentation and institutionalisation remains wide. The question is no longer whether IVR can work in a classroom, the evidence suggests it can, but rather what it takes for a school to sustain it beyond the initial enthusiasm, the external support and the early adopters.

2 Literature Review

Research on IVR in educational contexts has consistently documented its potential to enhance learning, particularly through increased engagement, presence and contextualisation (Dalgarno & Lee, 2010; Morgado, 2022; Dengel, 2022). In non-higher formal education, benefits have been reported especially in STEM (Science, Technology, Engineering, Mathematics) subjects, provided that adequate pedagogical and institutional conditions are in place (Jiwon et al., 2025; Ward et al., 2025). However, Hamilton et al. (2021) and Zhan & Nasri (2025) document that the vast majority of IVR interventions are short in duration and measure only immediate outcomes, without evaluating retention, dissemination or continuity after external support is withdrawn.

The notion of educational ecosystem has been theorised in the context of digital education, with Moreira (2018) arguing that digital technological evolution plays a determining role in reconfiguring educational ecosystems and learning environments. However, this conceptualisation has not been operationalised for immersive technologies in formal school contexts, nor does it model the articulation between the multiple actors that such implementation requires.

The literature on implementation offers relevant but partial contributions. Rogers (2003) proposed that innovation diffuses when it holds relative advantage, compatibility and observability, however diffusion does not guarantee sustainability. Coburn (2003) demonstrated that scaling without depth and ownership is an illusion of success. Fixsen et al. (2005) identified that most innovations fail in the transition to full operation, estimating that sustainability takes between two and four years. Fullan (2007) adds that deep institutional reform requires between five and ten years to consolidate. Beck et al. (2026) proposed the ETSIS framework for K-12 education, envisioning the adoption of emerging technologies (including IVR) as a sociotechnical-immersive system, and call for a research agenda to "*redesign assessment for emerging technologies, treat infrastructure and support as minimum requirements, make data governance explicit, describe environments in ways that travel across contexts, and invest in long-term teacher appropriation.*"

These frameworks explain the dynamics of change but do not model the articulation between actors that makes change possible and sustainable in IVR contexts. Governance and leadership are partially recognised as critical dimensions (Lyle et al., 2024), and models alternate between normative structures and power relations (Balarin, 2008; Wilkins & Mifsud, 2024), without operationalising the dynamic articulation of the ecosystem as a condition for sustainability. Individual adoption, frequently studied through UTAUT2 (Venkatesh et al., 2012), remains necessary but insufficient.

3 An Ecosystem Approach

This paper draws on an action research study conducted at CAISL, Carlucci American International School of Lisbon, a K-12 international school with approximately 750 students, where IVR was implemented in 8th and 9th grade classrooms using Meta headsets with PrismsVR software (Sacavém, 2025). The study documented the main challenges to IVR adoption at pedagogical and technical levels, confirming that immersion is not an automatic benefit but a property whose effects depend critically on implementation conditions (Jiwon et al., 2025).

The empirical basis of this paper is a master's action research study (Sacavém, 2025) conducted at CAISL across nine cycles of iterative implementation and reflection. Data were collected through an observer diary, document analysis, student questionnaires, and semi-structured interviews with the two participating teachers. The three challenges reported here: time coordination, content appropriation and cultural readiness, emerged from thematic analysis across these data sources.

The pilot involved two teachers and was considered successful. It was precisely this success that revealed the ecosystem complexity required for scaling. Moving from two teachers to many is not a matter of adding devices, it is a matter of coordinating a multi-actor ecosystem.

The actors comprising this ecosystem were identified through systematic reading of the empirical accounts documented in Sacavém (2025), where they appear throughout the action research cycles, in observer diary entries, exploratory interviews, and document analysis, in relation to the challenges encountered during implementation. For the purposes of this article, these actors were grouped into functional categories based on their primary role in the implementation process: pedagogical, leadership, support, and external. This categorisation is analytical and inductive, reflecting the functional interdependencies observed in the empirical context rather than a pre-established theoretical framework, (Table 1).

Table 1. Ecosystem areas and actors identified in the empirical context. Actor roles and interdependencies are subject to further empirical investigation

Categories	Actors Identified in the Empirical Context, (Sacavém, 2025)
Pedagogical area	Teachers, Students
Leadership area	Principal, Secondary Principal
Support area	IT Team, Administrative Staff, Parents
External area (software)	IVR content providers (PrismsVR), classroom management software providers
External area (hardware)	Headset manufacturers (Meta, Pico)
External actors (infrastructure)	Physical storage solution providers (device carts)

When scaling was considered, three interconnected challenges emerged that the pilot had not needed to resolve. Two of these were identified through the action research process documented in Sacavém (2025), in which the first author participated as researcher-participant. First, content appropriation, teachers need dedicated time to explore IVR content independently, testing headsets at home and aligning available experiences with their specific curricular goals, a process that is invisible in the pilot but critical for scaling. Second, cultural readiness, while some teachers embraced the technology enthusiastically, others showed resistance, revealing that scaling is not only a logistical challenge but also a cultural one, requiring deliberate change management at the institutional level (Fullan, 2007). Third, time coordination, bringing together teachers, leadership and technical staff for shared training requires institutional time that is rarely allocated by default, reflecting a pattern directly observed and experienced by the first author across multiple cycles, consistent with the epistemological stance of action research.

These challenges are not independent; they form an interdependent system. A teacher cannot appropriate content without time. Time cannot be allocated without leadership commitment. Leadership commitment is harder to sustain without external supplier support and clear curricular alignment. This interdependence is what the existing literature fails to model, and what an ecosystem approach must address. This paper proposes that sustained IVR adoption requires a model that maps these actors, their interdependencies, and the temporal and cultural conditions under which their coordination enables the transition from pilot to practice. This model is currently under development through further empirical research.

4 Discussion

This paper suggests implications for three distinct audiences. For researchers, the ecosystem mapping proposed here suggests that future studies on IVR in education may benefit from moving beyond measuring learning outcomes in short interventions, focusing instead on the conditions that enable sustained adoption, including governance, leadership distribution and inter-actor coordination. The tension between scaling as numerical expansion and scaling with depth (Coburn, 2003) remains unresolved in the IVR literature and represents a productive avenue for longitudinal investigation.

For school leaders, the arguments in this paper raise the possibility that the decision to scale IVR beyond a pilot may not be primarily a budgetary or technical decision, but rather an institutional commitment that requires deliberate allocation of time, structured teacher training, and a distributed leadership approach (Lyle et al., 2024). Whether the absence of these conditions is what keeps pilots from becoming practice is a question that empirical research needs to address.

For technology providers, the ecosystem mapping suggests that hardware and software suppliers may play a more central role in the coordination challenge than the literature currently acknowledges. Whether onboarding processes, technical support structures and content alignment with curricular goals function as conditions for sustainability is a question that future empirical research needs to address.

5 Conclusion

This paper argues that the transition from pilot to sustained IVR adoption in formal school contexts is not a technical challenge, it is an ecosystem coordination problem. The evidence gathered in a real school context (Sacavém, 2025), combined with the gaps identified in the implementation literature, point to the need for a model that maps the actors involved, their interdependencies, and the conditions that enable their articulation. Time, content appropriation and cultural readiness emerged as interdependent challenges that no single actor can resolve alone and are critical conditions for scaling IVR adoption from pilot efforts into institution-wide scenarios.

Further research is needed to develop and validate an ecosystem model grounded in longitudinal empirical evidence, integrating the perspectives of all actors involved. There are significant frameworks and theoretical proposals for such ecosystem models, but not practical guides or instruments on how to implement an institution-wide digital transition process of IVR adoption. The goal is to produce knowledge that is both scientifically relevant and practically useful for schools seeking to move beyond the pilot phase.

References

1. Beck, D., Elmendofr, D., Morgado, L. (2026). Emerging Technologies as Sociotechnical-Immersive Systems: A Framework and Research Agenda for K-12 Online Learning. Journal of Online Learning Research, 12(1), 121-138. https://doi.org/10.70725/638809gclyem
2. Coburn, C. E. (2003). Rethinking scale: Moving beyond numbers to deep and lasting change. Educational Researcher, 32(6), 3–12. https://doi.org/10.3102/0013189X032006003.
3. Dalgarno, B., & Lee, M. J. W. (2010). What are the learning affordances of 3-D virtual environments? British Journal of Educational Technology, 41(1), 10–32. https://doi.org/10.1111/j.1467-8535.2009.01038.x.
4. Dengel, A. (2022). What is immersive learning? 2022 8th International Conference of the Immersive Learning Research Network (iLRN), 1–5. https://doi.org/10.23919/iLRN55037.2022.9815941.
5. Fixsen, D. L., Naoom, S. F., Blase, K. A., Friedman, R. M., & Wallace, F. (2005). Implementation research: A synthesis of the literature. University of South Florida, Louis de la Parte Florida Mental Health Institute, The National Implementation Research Network.
6. Fullan, M. (2007). The new meaning of educational change (4th ed.). Teachers College Press.
7. Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: A systematic literature review of quantitative learning outcomes and experimental design. Journal of Computers in Education, 8(1), 1–32. https://doi.org/10.1007/s40692-020-00169-2.
8. Jiwon, H., Jiwon, S., & Mai, N. (2025). Implementing virtual reality in science education at South Korean high schools. Journal Emerging of Technologies in Education. https://doi.org/10.70177/jete.v3i1.2108.
9. Moreira, J. A. (2018). Reconfigurando ecossistemas digitais de aprendizagens com tecnologias audiovisuais. *EmRede, 5*(1), 5–15. https://aunirede.org.br/revista/index.php/emrede/article/view/305.
10. Morgado, L. (2022). Ambientes de aprendizagem imersivos. Vydia Journal of Social and Human Research, 1(2).
11. https://doi.org/10.18817/vjshr.v1i2.32.
12. Rogers, E. M. (2003). Diffusion of innovations (5th ed.). Free Press.
13. Sacavém, A. I. R. S. C. (2025). Realidade virtual na educação: Principais desafios à sua adoção numa instituição educativa [Dissertação de mestrado, Universidade Aberta]. Bibliotecas UAb.
14. Ward, T., Jenab, K., Ortega-Moody, J., Barari, G., & Molina Acosta, L. D. C. (2025). Virtual classrooms, real impact: A framework for introducing virtual reality to K–12 STEM learning based on best practices. Applied Sciences, 15(21), Article 11356. https://doi.org/10.3390/app152111356.
15. Zhan, Z., & Nasri, N. (2025). Immersive virtual reality in vocational school: A systematic literature review. International Journal of Academic Research in Progressive Education and Development. https://doi.org/10.6007/ijarped/v14-i1/24694