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MIRE - Mixed Reality in Education

Executive Summary

The current landscape of Mixed Reality (MR) applications in Education finds common employment in rendering 3D content in digital spaces. We noticed an unexplored area in the development of 3D-based activities that, combined with 3D content, could lead to comprehensive teaching experiences. Our project, in partnership with Vodafone and FifthIngenium, aims to fill this gap. These two companies asked us to work on the theme of using MR in Education to convey concepts instead of representing contents, giving us the freedom to develop activities without specific constraints on our creativity.

Our first design step was to identify the support for synchronous group work as an interesting scenario of use, considering its utility in both formal and non formal (thus also corporate) educational settings. This innovation resonates notably within the context of the agile methodology, amplifying its significance. After a brainstorming process, we chose to develop a word cloud activity to aid discussions, knowledge retention and decision-making. We tested this activity at the Politecnico di Milano Open Day and the Parini High School, with largely positive feedback on its user-friendliness, functionality and perceived usefulness. Around 80.5% of the Open Day participants found the system practical, and 71.4% of the Parini participants appreciated the collaboration with other students in MR.

Future developments includes the implementation of agile project management tools and a hierarchical user structure into the MR system. These enhancements are aimed at catering to complex project management needs in both academic and corporate settings. While these developments are promising, they will require additional research and testing to ensure their effectiveness.

The project's innovative development, practical application, and comprehensive evaluation have been summarized in an article accepted as a full paper and presented at EDMEDIA in Vienna, one of the world's most important conferences on the topic of integrating technologies in Education.

Key Words

Education, Mixed Reality, Project Work

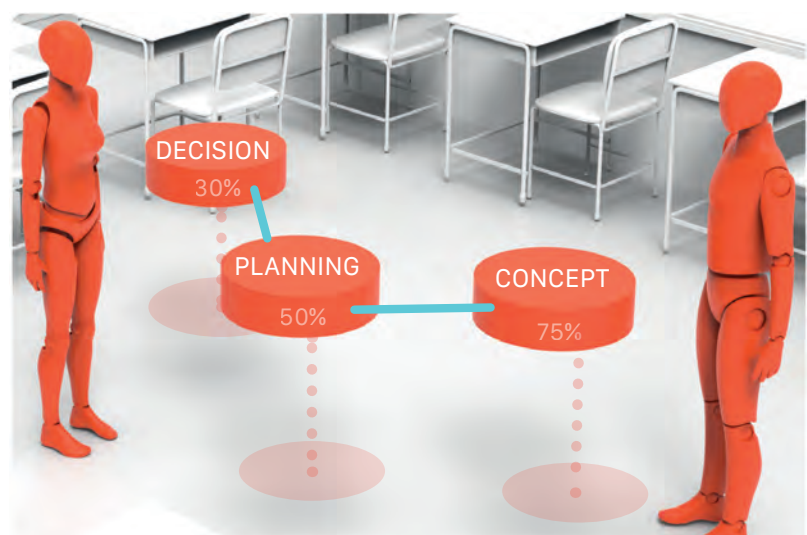
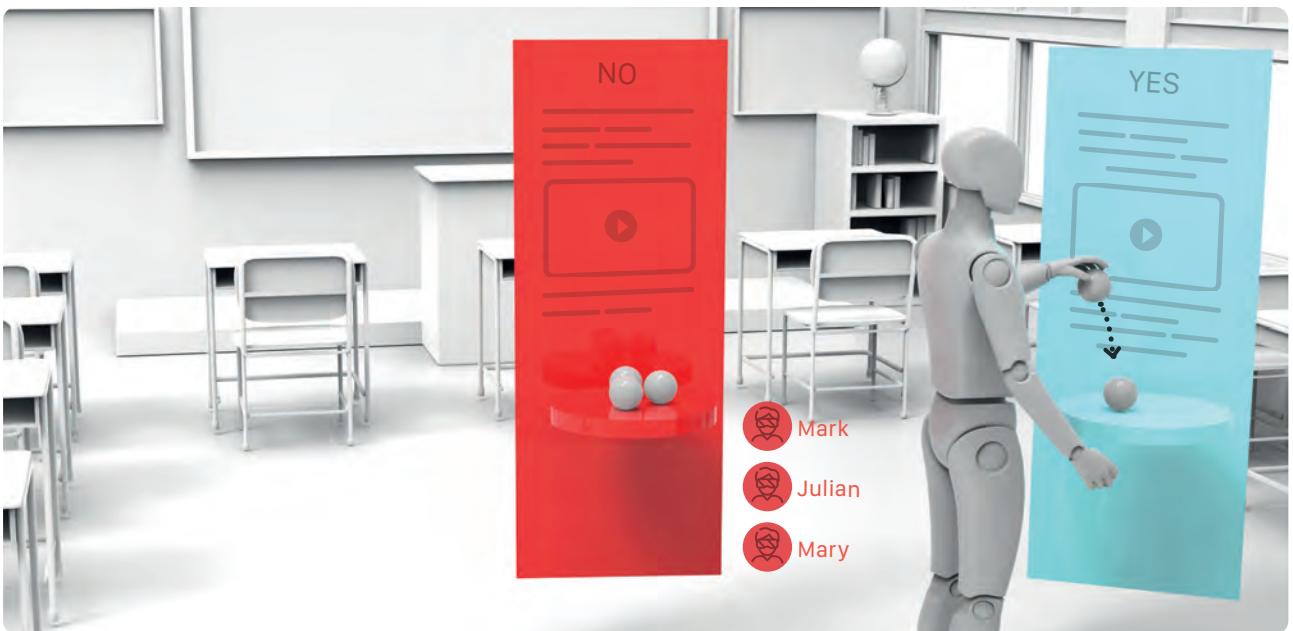
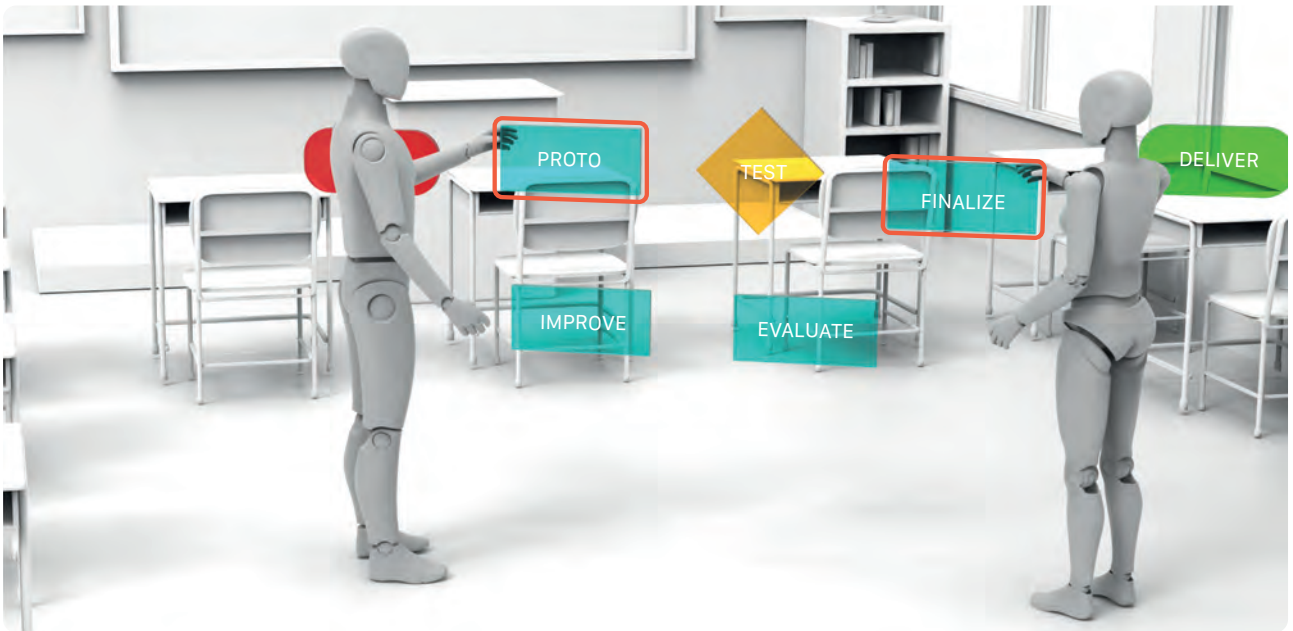


Figure 1. Concept of the Thematic Islands Experience.



Project description written by the Principal Academic Tutor

For decades, "Mixed Reality" has garnered increasing interest across various sectors, including education. Its primary focus lies in replicating a wide range of objects, which may prove intricate, hazardous, or simply unattainable within the confines of a school or university classroom. Examples abound, from archaeological artifacts and historical building reconstructions to simulating a "beating heart," intricate machinery, or 3D city plans. As MR advances in tandem with the evolution of enabling devices, it demonstrates tremendous promise as a valuable tool in both formal education and corporate training settings.

Curiously, while the development of 3D content has flourished, there has been a noticeable absence of a parallel emphasis on the educational activities that, combined with this content, form a complete educational experience. To draw an analogy, it's akin to selecting the most suitable textbooks for a school lesson but neglecting to consider the activities that students are expected to engage in. Undoubtedly, any educational experience hinges on the integration of content and activities.

To bridge this gap, a collaborative effort was initiated among Vodafone Italy, the startup FifthIngenium, and the HOC laboratory at Politecnico di Milano, leading to the inception of the MIRE project. The core objective of the MIRE project was to explore the development of educational activities in MR, with a specific emphasis on supporting groups engaged in collaborative projects, whether in-person or remote—a common scenario in university education. Vodafone also emphasized the incorporation of Agile design principles into the project.

Following an initial phase of "naive" creative brainstorming, unencumbered by preconceived notions of others' work, the team undertook a comprehensive analysis of the current state of the field. By merging insights from both these sources—unbiased brainstorming and existing literature—an overarching concept was crafted to support group project development while adhering to Agile methodology principles. Central to this concept were "activity islands," accessible both synchronously and asynchronously, with progress visible to all team members. To assess the usability and effectiveness of this approach, one of the proposed activities, brainstorming aided by a word cloud, was selected for development to a maturity level suitable for end-user testing. The choice of this activity was motivated by its flexibility for use in diverse contexts and the specific technical challenges it presented. The "word cloud" activity was subjected to usability and perceived effectiveness tests in two real-world contexts.

The outcomes of the project were presented as a full paper at the international EdMedia conference held in Vienna in July 2023. Furthermore, they contributed to the development of an educational product by the stakeholder companies, catering to schools, universities and the corporate sector.

Team description by skill

The team members with a background in design disciplines, namely Bianchini and Brattelli, were primarily responsible for crafting the user experience. Their knowledge ensured that the end product was not only functional but also intuitive and engaging for the users. They worked on refining the user journey, ensuring that the interface was aesthetically pleasing and that users could navigate it effortlessly. On the other hand, team members who majored in engineering disciplines, namely Concialdi, Fasiello, and Gravina, tackled the more technical facets of the project. Their domain of work revolved around understanding and resolving technical challenges, implementing functional solutions, and ensuring the robustness of the technical infrastructure. Their deep dive into the technical architecture meant they were examining the foundational elements that would support the experience, ensuring its stability, scalability, and efficient performance. FifthIngenium, our technological partner, provided the resources for realizing the designated experience (the word cloud). Throughout the implementation phase, our primary point of contact within the start-up was Leonardo Scapolan. Their combined efforts ensured that the user experience was underpinned by a solid technical foundation. We worked together to translate our project concept into an actual experience, while also enriching the project with new features and functionalities.

Goal

The "MIRE" project aims to address the challenges and opportunities arising from the integration of Mixed Reality in educational settings. Anchored in a collaborative partnership between Hoc-Lab at Politecnico di Milano, the telecommunications company Vodafone, and the Milan-based startup FifthIngenium, the project endeavors to innovate educational methodologies by creating a comprehensive set of tools for MR integration in classrooms. Going beyond the mere visualization of 3D objects or basic interactive experiences, MIRE seeks to facilitate a concept-driven, immersive, and engaging learning process that utilizes MR's capabilities for depicting abstract ideas, interrelationships among concepts, and various forms of knowledge.

The project aspires to close the existing gap between virtual content creation and the effective instructional design supporting it, while also acknowledging the need for flexible, versatile, and scalable solutions that cater to a diverse student population. The primary objective is to align with Mitch Resnick's "low-threshold, high-ceiling" concept, making MR technology accessible to educators for seamless integration into varied educational settings, ranging from classroom presentations to remote learning scenarios.

Additionally, the project is sensitive to the broader context of educational needs, recognizing the importance of preparing students for the modern labor market. By achieving these ambitious objectives, MIRE aims to serve as a catalyst for the democratization of educational technology, effectively transforming how educators and students interact with complex concepts and with each other, both in academic and corporate environments. This multi-faceted goal is further underlined by the project's secondary task of producing academic papers to validate its efficacy and explore potential commercial applications, ensuring that the project is grounded in rigorous academic and market-oriented validations.

Understanding the problem

The MIRE project initially aimed to cater to an educational environment, focusing on students and teachers from K-12 to higher education. Its central objective was to enrich educational and collaborative experiences by leveraging Mixed Reality technologies. However, as the project evolved, it garnered interest in the corporate sector, thereby necessitating a pivot in target audiences, design decisions, and priorities. This shift led to an intricate, multi-dimensional challenge.

To tackle this, the team engaged in a comprehensive analytical exercise employing methodologies like PEST, SWOT, and Stakeholder Analysis. PEST analysis allowed the identification of external risks and opportunities stemming from political, economic, social, and technological factors. One key finding was the alignment with the United Nation's 4th Sustainable Development Goal, "Quality Education," which added political impetus and prospective public funding to the project. On the flip side, high initial costs for MR technologies and societal concerns about data misuse formed significant barriers.

The SWOT analysis delved deeper, combining internal and external perspectives. It revealed that while the project's strength lay in its interactive and engaging features, weaknesses like the risk of simulation sickness, high development costs, and a potential lack of user immersion required urgent attention. Externally, the post-Covid-19 emphasis on remote collaboration stood out as an opportunity, whereas the novelty of the technology emerged as a threat, given that users could find the technology superfluous, in comparison to existing traditional tools, or hard to adapt to.

Stakeholder Analysis formed another critical layer of understanding. It helped categorize the actors involved and assess their potential impact and needs, ranging from administrative authorities to parents and students. The significant revelation here was the need to educate potential users or build an intuitive system with lower need for training, particularly teachers who might be reluctant to adopt new technologies due to a lower level of ICT literacy. This understanding

was further deepened by interviews and hypothesis validation. The incorporation of user personas finally made the user requirements concrete. Each persona – whether a student, teacher, or school manager – had a set of unique needs and challenges, from the necessity for immersive experiences to concerns about inclusivity and remote engagement, or ultimately budget management.

In summary, the problem's complexity was not just technological but deeply embedded in the socio-economic context, user adaptability, and a rapidly evolving landscape. Addressing these would necessitate not just technical acumen but also keen insights into human behavior, economic constraints, and the educational and corporate ecosystems.

Exploring the opportunities

The transformational scope of the Mixed Reality for Education (MIRE) project is indeed compelling, offering a host of opportunities that could redefine the paradigms of educational and corporate training. One of the most immediate opportunities lies in its capability to facilitate deeper comprehension and collaboration among learners. In a landscape that is increasingly remote and digital, MIRE's focus on "concepts" over "objects" holds the promise of making learning experiences more meaningful and less constrained by physical boundaries.

The project's alignment with Vodafone Business and 5G technologies adds another layer of opportunities, mainly centered around low-latency, high-quality mixed reality interactions. This technological partnership not only reinforces MIRE's educational potential but also situates it as a viable commercial product within a broader ecosystem of services. This dual alignment could open new funding avenues and partnerships, potentially accelerating its development and adoption.

Additionally, MIRE's pivot toward "collaborative and remote activities in mixed reality" could serve as a timely solution for the ongoing challenges in remote learning and work. Its adaptability to both educational and corporate settings makes it a versatile tool, underlining its potential to become a market leader in providing MR-based collaborative solutions. This is not just about constructing a virtual classroom or a training module but about creating a holistic ecosystem that can adapt to various needs and situations.

The empirical research carried out so far validates the feasibility and benefits of the project.



Figure 2. Word Cloud with Voting Menu.

The next steps, which include the creation of a comprehensive library of didactic experiences and rigorous real-world testing, could serve as a springboard for future expansions and refinements. Given that the experiences are envisioned to be dynamic and customizable, MIRE stands to benefit from a continuous feedback loop, making it a continually evolving and improving product.

In summary, MIRE is positioned at the intersection of technological innovation and educational need, thereby holding a unique opportunity to redefine learning and collaboration for the 21st century. Its focus on abstract concepts over tangible objects, low-latency interactions enabled by 5G, and adaptability to both educational and corporate settings are promising avenues that could shape its future success and impact.

Generating a solution

The endeavor to create a Mixed Reality (MR) educational tool presents a highly nuanced and layered project architecture. With a focus on the "word cloud" activity, the MIRE system aims to facilitate educational practices in both academic and corporate settings by employing the MR medium. In this report, we will describe the key phases that led to the generation of this innovative solution.

Conceptual Foundation

The research began with a panoramic view of potential learning experiences that could benefit from MR technology. Among the host of conceptualized activities, the "word cloud" stood out for its adaptability and interactivity, thus becoming the nucleus for further development. The decision to focus on this activity is crucial: it marks the genesis of a tool that can adapt to a variety of learning environments, be it a university lecture or a corporate brainstorming session.

Technical Backbone

The project engaged extensively with the pragmatic aspects of realizing the "word cloud" in MR. It employs Microsoft's Mixed Reality Toolkit (MRTK) to ensure compatibility across a broad spectrum of devices. The commitment to cross-platform functionality is not merely a matter of convenience but a strategic initiative to democratize access to educational resources. Furthermore, the system addresses the pressing concern of technological obsolescence, thereby making it future-proof.



Figure 3. A Group of Students Creating a Word Cloud at Politecnico di Milano Open Day.

Main bibliographic references

S. Bauro, C. Campanella, L. Corinaldesi, N. Di Blas, M. T. Faga, C. Franch-Arnau, G. Pinotti and M. Valoriani, "Mixed Reality in Education: Towards a New Paradigm.," in Society for Information Technology & Teacher Educational Conference, San Diego CA, United States, 2022.

S. Bauro, C. Campanella, L. Corinaldesi, N. Di Blas, M. T. Faga, C. F. Arnau, G. Pinotti and M. Valoriani, "Mixed Reality in Education, for any School Subject," in EdMedia+ Innovate Learning, 2022.

S. Bauro, L. Bianchini, W. Brattelli, C. Campanella, G. Concialdi, L. Corinaldesi, M. Di Marco, N. Di Blas, M. T. Faga, A. Fasiello, M. Gravina, L. Scapolan and M. Valoriani, "Supporting Project Work with Mixed Reality," in EdMedia + Innovate Learning 2023, Vienna, 2023.

C. Hughes, C. Stapleton, D. Hughes and E. Smith, "Mixed reality in education, entertainment, and training," IEEE Computer Graphics and Applications, vol. 25, no. 6, pp. 24-30, 2005.

J. Marks and M. Thomas, "Adoption of virtual reality technology in higher education: An evaluation of five teaching semesters in a purpose-designed laboratory," Education and information technologies, vol. 27, no. 1, pp. 1287-1305, 2022.

B. Marr, "Extended Reality In Education: The 5 Ways VR And AR Will Change The Way We Learn At School, At Work And In Our Personal Lives," Forbes, 19 April 2021.