TOWARDS AN EDUCATION SYSTEM AIMED AT ENHANCING THE EMBODIED, ENACTIVE AND INTERACTIVE EXPERIENCE THROUGH NEW REALITIES

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ABSTRACT
The rapid evolution of immersive XR technologies has led to enhanced experiences by blurring the line between the real (physical) and unreal (virtual) worlds. However, there is a dearth of research clarifying the types of learning paradigms to consider when integrating immersive technologies in design education and enhancing learner experience. How can we further enhance our design education system by using immersive technologies to upgrade learning experiences? What type of approach is appropriate to make the best use of the unreal in design education to enhance learners' experiences in the real? The integration of knowledge from recent neuroscience research into education, through a multidisciplinary translational approach, can be transformative for advancing the comprehension and development of new learning experiences. This research aimed to clarify several questions. It began by (1) reviewing current trends and the role of immersive technologies. Next, it (2) identified their role and value in design education, and (3) highlighted the limitations and possibilities of using immersive technologies as tools in design education with *The Enactive Embodied Experience Model*. Finally, (4) it proposed an approach based on recent neuroscience research. This approach uses a multidisciplinary translational strategy to advance the comprehension and development of new learning experiences in design education and to provide experience-based knowledge through immersive technologies. The findings of this research will act as guidelines for the implementation of immersive technologies in design education and will be one of the considerable methods to enhance students' enactive learning experiences.

Keywords: Embodied-Enactive-Interactive, immersive technology, experience-based knowledge

1 INTRODUCTION
The rapid evolution of immersive technologies such as, Virtual Reality (VR) and Augmented Reality (AR), blur the lines between the *real* (physical) and *unreal* (virtual) worlds by enabling the creation, manipulation, and testing of realistic and complex immersive experiences and solving many of the design constraints. However, accelerating forward and making these technologies mainstream design tools can be hindered by the need for human resource training, rigid time schedules, budget issues, and other constraints of the design industry. Failing to overcome this challenge will lead present and future designers to face difficulties in exploring new possibilities, gaining new knowledge, and eventually unlocking the full potential of immersive technologies as design tools for enhancing the human experience. How can we further enhance our design education system by utilizing immersive technologies to upgrade learning experiences? What type of approach is appropriate to unlock the full potential of the *unreal* (immersive technologies) as design tools to enhance human experiences in the *real* world?

A solution to this is to rethink the role of immersive technologies in the learning experience provided by the design education system. Nowadays, design students enter higher education with significant computing knowledge and higher expectations from academia to introduce them to relevant theoretical as well as practical knowledge and application of high-end immersive tools for a successful transition into the design industry. Even though immersive technologies have indeed been introduced in education for several years, they are yet to gain broad acceptance in design schools. This research aimed to gain clarity to these issues by, (1) reviewing the current trends and role of immersive technologies in design industry, (2) identifying their role and value in design education, (3) highlighting the limitations in using immersive technologies as design education tools with *The Enactive Embodied Experience Model*, and (4) proposing an approach in design education to provide experience-based knowledge using immersive technologies.

Designs are concerned with how things work, how humans interact with something, and how they solve real-world problems and human needs. The issue with traditional design practices is that they were based on the designer's or engineer's logical assumption of how they wanted or expected them to be used, not the way the users would use them. In future design, human cognitive and emotional demands must be prioritised over high-end and technologically advanced designs. Current design practices such as industrial, engineering, and interactive design are adopting this approach by producing form-function-based objects upon analysing what the users expect from the objects or services and their experience, i.e., human-centred experience design. Further implementation of this approach requires multiple design prototypes and testing to ensure that the users' needs and problems are met.

2 LITERATURE REVIEW

Immersive Extended Reality (XR) technologies, encompassing Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), have revolutionized how we interact with digital content. By blending the digital and physical realms, these technologies create experiences where the real and unreal seamlessly converge, offering users a new dimension of interaction. VR immerses users in entirely digital environments, AR overlays virtual objects onto the real world, and MR combines elements of both to create interactive environments that integrate real and virtual elements. This fusion of realities enhances the perception of presence, making digital interactions feel as tangible and immediate as those in the physical world. In education, particularly design education, these technologies offer a rich, interactive canvas for students to explore concepts, visualize designs in three dimensions, and engage with content in a deeply personal and impactful way. By simulating real-world scenarios and enabling hands-on experiences without the constraints of physical materials or geographic boundaries, immersive XR technologies have the potential to revolutionize not only design but also broad learning methodologies, making education more accessible, engaging, and effective. To delve into the potential of immersive technologies in revolutionizing design education systems and learning experiences, it's essential to build upon the recognition of the existing research gap. Understanding that the integration of Extended Reality (XR) technologies—Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR)—into design education lacks a comprehensive pedagogical framework, we can begin to explore innovative avenues for their application. This exploration aims to not only harness the technological capabilities of XR but also to align these tools with educational strategies that significantly enhance learning outcomes. In other words, it is expected that understanding how the experiences that build individual knowledge and the personalized perspectives (*the Innate/Inherent Subjective Filters* in this study) interact with the introduction of immersive technologies can provide direction for immersive education.

2.1 Current Trends in Immersive Technologies & Learning Paradigms in Design Education

Immersive technologies offer unparalleled opportunities to enhance the evolving learning paradigms in design education. Specifically, VR and AR provide simulated environments and scenarios that are otherwise impossible or impractical in a traditional classroom. These innovations allow students to explore, experiment, and refine their designs in a safe, virtual space, fostering an environment ripe for active learning and discovery. This, in turn, amplifies the principles of constructivist learning. Additionally, MR and AR technologies can enhance collaborative projects, even when participants are geographically dispersed. They enable students to share and interact within virtual spaces, collaborate in real-time, and provide immediate feedback, effectively overcoming physical and geographical barriers. This promotes a community of practice, where students gain from diverse insights and feedback from their peers. Moreover, immersive technologies can replicate real-world environments and conditions, offering students the chance to apply their designs in various contexts and scenarios. This approach not only enriches the learning experience but also equips students with the necessary skills and understanding to tackle real-world design challenges, enhancing experiential learning. The integration of immersive technologies into design education promises to significantly enrich learning paradigms, providing more interactive, engaging, and personalized experiences. As these technologies continue to evolve, their role in education is set to expand, fundamentally transforming how design is taught and learned. However, when implementing these possibilities in design education, an important point is to reconsider the perspectives and methods of immersive education tailored to the knowledge and experience of each individual learner. This leads us to critical questions for the future of design education: How can immersive technologies improve learning experiences? And what are the most effective strategies for incorporating virtual elements into design education to enhance real-world outcomes? These questions will be addressed in the Methodology section.

3 METHODOLOGIES AND DISCUSSIONS

The revised *Enactive Embodied Experience Model* (for the previous model, refer to references 1,2 and 3), depicted in Figure 1, advances our understanding of how affective processes shape personal choice and desire through the lens of *an innate/inherent subjective filter*. This filter posits that individual experiences and transformations cultivate a distinct perceptual lens for each person. Central to the model is the mechanism by which human sensory receptors—such as the eyes, ears, and nose—capture environmental stimuli. This sensory data is then synthesized in the brain, influenced by a filter that modulates affective responses. Additionally, the model introduces the concept of a 'driven filter', either logical or aesthetic, which plays a pivotal role in the development of an individual's unique subjective filter. As illustrated in Figure 1, this driven filter elucidates the dynamic interplay between the innate subjective filter and the process of sentient behavioural modification. This process, informed by personal experiences, culminates in the manifestation of sentient behaviour. The notion of *the oriented/driven filter* is critical in understanding how it guides the evolution of *the innate subjective filter*, be it logical or aesthetic. Individuals with a predilection for logic-oriented learning—such as language or mathematics, which demands a conceptual grasp of principles—tend to enhance their logic-focused dimension over the aesthetic one. Conversely, those inclined towards aesthetic-oriented learning, exemplified by pursuits in art and music, which require a more flexible and intuitive approach, are likely to cultivate their aesthetic dimension. It is posited that these divergent learning orientations significantly influence and nurture the individual's innate subjective filter, reinforcing the model's premise on the formation of unique perceptual lenses shaped by personal experiences. In other words, by individualizing the stimuli provided through immersive technologies according to each person's 'driven filter', it is expected that the same stimuli can lead to a diversification of experiences influenced by the inherently modified subjective filter unique to each individual.

In the domain of design education, integrating virtual elements opens transformative paths to enrich learning experiences. By embracing immersive technologies, educators create environments where students do more than just absorb theoretical knowledge; they apply it within simulated real-world contexts, bridging the gap between classroom learning and professional practice. This holistic approach fosters the development of a unique perceptual lens for each student, rooted in experiential learning and shaped by the nuances of human emotion and cognition, as detailed in the revised Enactive Embodied Experience Model. This includes methods such as Project-Based Learning with Immersive Technologies, Gamification, and Real-World Simulations and Case Studies, described as follows: (1) Project-Based Learning with Immersive Technologies: Utilizing VR and AR transforms project-based learning into an engaging activity that reflects the complexity and dynamism of real-life professional scenarios. This approach enables students to design and test virtual models, offering immediate feedback and enhancing engagement through a hands-on, experiential learning process. By tailoring stimuli (e.g., stimuli based on the characteristics of sensory organs such as sight, smell, and hearing) to each individual's specific 'driven filter', and by providing these stimuli at varying frequencies and intensities, it is expected that, even with the same amount of time and technology invested, more effective immersion can be achieved compared to existing methods. (2) Gamification: Integrating game design elements into the curriculum, a method known as gamification, significantly increases student motivation and engagement. Introducing challenges and competitions in a virtual environment not only makes learning more enjoyable but also strengthens the connection with the material. By adjusting the level of challenges to suit each individual's specific driven filter, it will enable the practical implementation of personalized education rather than a one-size-fits-all approach. (3) Real-World Simulations and Case Studies: Employing VR or AR to mimic real scenarios provides students with practical insights and prepares them for the diverse challenges of the design industry. This experiential learning method allows for the application of theoretical concepts in real-life situations, thus improving the educational experience. By selecting simulation subjects and conducting in-depth case studies tailored to each individual's specific driven filter, the accumulated data will make it easier to identify the types and explanations of simulations suitable for that individual and to point out specific issues. This will enable individualized learning through diversified simulations based on the innate subjective filter.

The strategic implementation of these methods enables educators to fully harness the potential of immersive technologies, not only elevating the design education experience but also equipping students with the skills necessary for success in the contemporary design landscape. Furthermore, these pedagogical strategies foster the growth of individual subjective filters, as informed by *the Enactive Embodied Experience Model* (Figure 1). This model illuminates the intricate relationship between affective processes and personal development, highlighting the role of logical and aesthetic 'driven filters' in shaping one's unique perspective. Whether through logic-oriented subjects like language and mathematics or through aesthetic pursuits such as art and music, these varied learning orientations significantly influence and enrich the individual's perceptual lens, promoting a culture of innovation and originality in design proposals and enriching the overall learning and creative process. In other words, the innate subjective filter that each individual is born with is strengthened and integrated with a specific 'driven filter' (logical or aesthetic) through the individual's experiences and learning. This development of the subjective filter leads to personalized understanding and accumulation of knowledge, even in response to the same external stimuli.

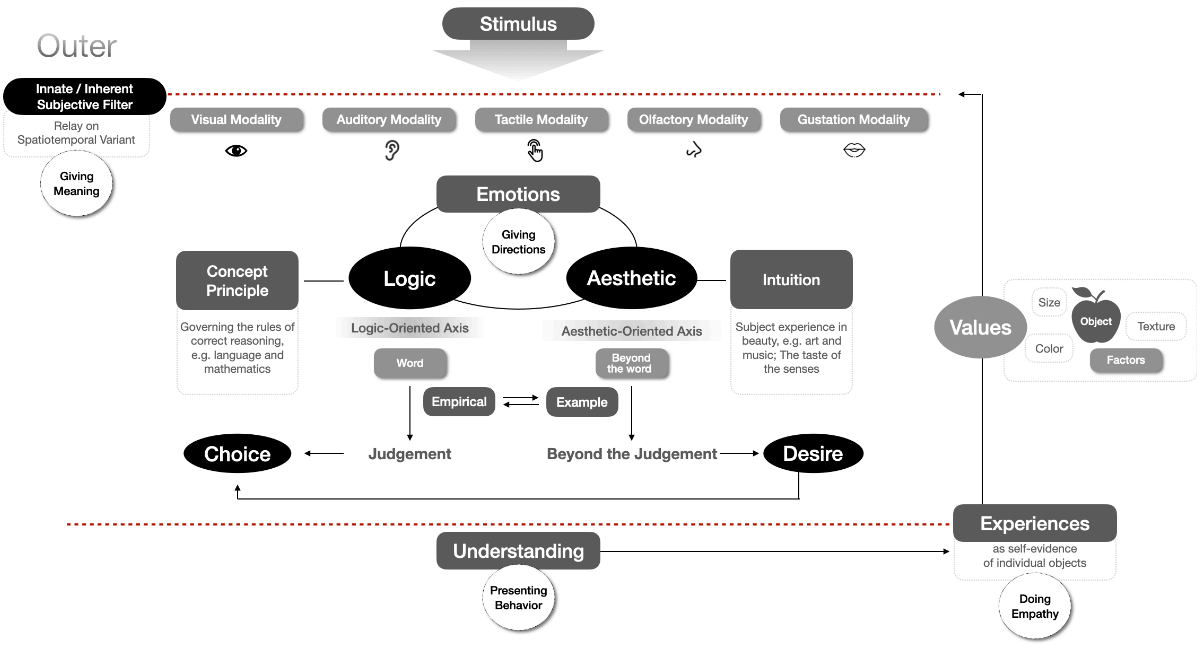

Figure 1. The Enactive Embodied Experience Model which explains the relationship between an innate / inherent subjective filter and the individual sentient behavioural modification process through their experiences, resulting in sentient behaviour by Kim

The inherent subjective filter not only endows individual meaning based on one's experiences and understandings but also underscores the significant differences between human cognition and Artificial Intelligence (AI). Humans interpret and integrate external information through a deeply personal and constantly evolving lens, whereas AI processes data based on predefined algorithms and models, lacking the capacity to be influenced by emotions or to adapt from experiences. This distinction highlights the nuanced and dynamic nature of human decision-making, wherein emotions, personal experiences, and the subjective interpretation of stimuli play pivotal roles. In contrast, AI's decision-making relies on logical analysis and pattern recognition, which, although powerful, fails to grasp the personal significance or emotional value that humans attribute to their choices and perceptions. In other words, individual experiences and understanding through the inherent subjective filter provide hints about the importance of personalization in immersive technology within design education.

Incorporating immersive technologies into design education presents a unique blend of challenges and opportunities, especially when analysed through *The Enactive Embodied Experience Model*. This model suggests that learning experiences are processed through cognitive frameworks unique to each individual, which can evolve or be further reinforced through new experiences. Within the realm of design education, integrating immersive technologies provides valuable insights into the capacity of these tools to reshape cognitive filters that fundamentally influence our understanding and application of design concepts. Thus, the critical question emerges: how can we effectively facilitate this transformation? Insights from neuroscience and learning within immersive environments suggest several effective approaches. Neuroscience, which explores the nervous system and brain, has unveiled crucial insights into our learning processes and the profound impact immersive experiences can have on educational outcomes. Recent studies have started to reveal how our brains process, store, and retrieve information, especially within immersive learning spaces enabled by VR, AR, and MR. This summary highlights key neuroscience findings relevant to education, with a focus on how immersive experiences influence the brain.

Immersive environments significantly boost learner engagement and attention. By immersing learners in virtual scenarios that mimic the real world, their sensory systems are fully engaged, which allocates more attention to the task. This increased focus supports deeper learning and better retention of information due to enhanced engagement and attention. Moreover, neuroscience has shown the critical role emotions play in learning and memory. Immersive experiences can provoke strong emotional responses because they can simulate real-life situations. These emotional reactions are linked to the amygdala, a brain region involved in emotional processing and crucial for memory formation and retrieval. Consequently, learning experiences that evoke emotions are more likely to be remembered due to the emotional connection and memory formation. Interacting with immersive technologies can also boost problem-solving abilities and creativity. The interactive nature of VR, AR, and MR environments prompts learners to explore, experiment, and critically think about encountered problems. This active learning approach fosters higher-order thinking skills such as analysis, evaluation, and creation, essential for the 21st-century workforce, enhancing problem-solving skills and creativity. Immersive learning experiences promote neuroplasticity, the brain's capacity to form new neural connections in response to learning and experiences. This is vital for acquiring skills and mastering complex concepts. By engaging multiple senses and providing hands-on experiences, immersive technologies enhance the brain's adaptability and learning capacity, improving cognitive functions and knowledge retention.

Immersive learning experiences, while offering unique opportunities, also pose challenges. One significant issue is the risk of cognitive overload, where the brain is overwhelmed by an excess of information from virtual environments. Another critical concern is the imperative to develop educational content that fully harnesses the capabilities of immersive technologies without compromising the quality of education. *The Enactive Embodied Experience Model* plays a crucial role in this context (Figure 1). This model elucidates the interconnectedness of affective processes and personal development, highlighting how both logical and aesthetic preferences—or 'driven filters'—shape our distinct perspectives. These unique viewpoints allow us to concentrate on design education issues within an aesthetic-related learning framework, which cannot be fully understood through a purely logic-driven filter. Whether through logical disciplines such as language and mathematics or aesthetic fields like art and music, these varied approaches to learning profoundly influence and enhance our perceptions. This could cultivate a culture of innovation and creativity in design proposals, thus enhancing both the educational experience and the creative process.

4 CONCLUSIONS

The intersection of design education and immersive technology—VR, AR, and MR—presents an unparalleled opportunity to revolutionize how we teach and learn design. By moving away from a predominantly theoretical approach to one that prioritizes hands-on, experiential learning, we can better prepare students for the complexities of real-world design challenges. This shift requires not just an investment in new technology but a reimagining of the curriculum to make learning more interactive, engaging, and effective. As we integrate these technologies, we must also address challenges such as accessibility and the development of relevant educational content. By leveraging VR, AR, and MR, we can create a more immersive learning environment that fosters creativity, collaboration, and problem-solving skills—key competencies for any future designer. The question for us, as educators and researchers, is not if but how we will embrace these technologies to enrich design education and better prepare our students for the future.

In the context of "Towards an education system aimed at enhancing the embodied, enactive, and interactive experience through new realities," the focus shifts towards reimagining the educational landscape. This is achieved by leveraging emerging technologies to craft more immersive, interactive, and engaging learning environments. Such an approach acknowledges the constraints of traditional education systems, which tend to prioritize theoretical knowledge over practical, hands-on learning experiences. By incorporating technologies based on *The Enactive Embodied Experience Model* (Figure 1), this initiative underscores the importance of how both logical and aesthetic preferences—or 'driven filters'—influence our unique viewpoints. The proposal aims to cultivate a learning atmosphere that accentuates embodied learning. Here, students learn through action, experiencing, and interaction within simulated environments that replicate real-world scenarios. This model emphasizes the integration of cognitive processes with physical experiences, thereby offering a holistic approach to education. By doing so, it encourages students to apply logical reasoning and aesthetic judgment in concert, enhancing their ability to navigate complex design challenges. *The Enactive Embodied Experience Model* provides a theoretical framework that illuminates how individuals perceive and interact with the world through a blend of sensory experiences and cognitive interpretations. It suggests that learning is most effective when it is situated in contexts that engage the learner's body and mind in active exploration and problem-solving.

In this reimagined educational paradigm, design academic field researchers are encouraged to explore how these technologies can be seamlessly woven into the curriculum. The goal is not just to integrate new tools for the sake of novelty but to fundamentally transform the learning process. This transformation involves making education more dynamic and responsive to the needs of students, preparing them for the complexities of contemporary and future design landscapes. The context centres around three key dimensions: (1) Embodied Learning: This dimension focuses on learning experiences that engage the whole body, allowing students to gain knowledge through physical interaction with their environment. Technologies like VR can simulate environments where learners can physically manipulate objects, conduct experiments, or perform tasks, enhancing their understanding through physical experience. (2) Enactive Learning: Enactive learning emphasizes active engagement and interaction with the learning material. Instead of passively receiving information, students actively construct knowledge by exploring, experimenting, and solving problems. AR applications, for instance, can overlay digital information onto the physical world, enabling students to interact with both simultaneously, thereby deepening their engagement and comprehension. (3) Interactive Experience: This aspect highlights the importance of interactivity in learning, where students are not mere spectators but active participants. Through MR and other interactive technologies, learners can collaborate in shared virtual spaces, engage in simulations that adapt to their actions, and receive immediate feedback, making the learning process more dynamic and personalized.

The proposed educational system combines three core dimensions to address the shortcomings of traditional methods. It envisages an inclusive learning environment engaging learners from diverse backgrounds, nurturing exploration, innovation, and creativity. This method strives to furnish students with versatile skills and innovative thinking necessary for navigating contemporary society. By integrating technologies grounded in *The Enactive Embodied Experience Model*, the system highlights how both logical and aesthetic preferences shape our viewpoints. This initiative aims to foster a learning atmosphere that emphasizes embodied learning, essential for design educators and researchers. This forward-looking approach ensures that the educational system remains adaptable and responsive to the changing needs of learners and the broader societal landscape.

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