VIRTUAL REALITY IN HOSPITAL EDUCATION: INTEGRATING IMAGERY AND IMMERSIVE LEARNING FOR HOSPITALIZED STUDENTS

REALTÀ VIRTUALE E SCUOLA IN OSPEDALE: INTEGRARE IMAGERY E APPRENDIMENTO IMMERSIVO PER STUDENTI OSPEDALIZZATI

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ABSTRACT
The study explores the integration of school in hospital, imagery and virtual reality to provide immersive and meaningful educational experiences. Based on theories such as Dual Coding, Multimedia Learning and Constructivism, it proposes a pedagogical model that values affective, cognitive, motivational and collaborative aspects for personalised and inclusive learning in hospital settings.

Lo studio esplora l'integrazione tra scuola in ospedale, immaginazione e realtà virtuale per offrire esperienze educative immersive e significative. Basato su teorie come Dual Coding, Apprendimento Multimediale e Costruttivismo, propone un modello pedagogico che valorizza aspetti affettivi, cognitivi, motivazionali e collaborativi, per un apprendimento personalizzato e inclusivo nei contesti ospedalieri.

KEYWORDS
Hospital Education, Virtual Reality, Immersive Learning, Imaginative Education
Educazione in ospedale, Realtà virtuale, Apprendimento immersivo, Educazione Immaginativa

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Introduction

Hospitalization in developmental age, especially if prolonged, represents a critical event that can significantly compromise the integral development of the child. It affects not only psychophysical balance (Hagglof, 1999), but also the continuity of the educational, social and emotional trajectory (Rokach, 2016). For children and adolescents with chronic conditions, school is often characterized by significant interruptions that distance them deeply from the experiences of their peers. The need for frequent hospital admissions, in fact, leads to a substantial loss of school days, with direct repercussions on performance and participation in educational activities (Hopkins et al., 2014). This discontinuity in the educational process is associated with a higher risk of early school leaving (Emerson et al., 2016; French et al., 2013), with a consequent reduction in the probability of completing compulsory education or accessing university courses (Haas Fosse, 2008). Prolonged withdrawal from the school environment not only hinders cognitive progress, but can generate emotional and relational barriers, manifesting themselves through behavioral difficulties, decreased motivation, worsening performance and critical issues in school reintegration (Hay et al., 2015; Fotheringham, 2021). These difficulties, combined with disconnection from the school and social context, can compromise the overall well-being of the student, affecting self-esteem and self-determination processes (Bruce et al., 2012). In some cases, sick students can be subject to social exclusion or bullying, with repercussions on the relational and identity level (Forrest et al., 2011), which make school reintegration and the processing of the experience of illness even more complex. In this scenario of vulnerability, the School in Hospital (SIH) takes on a central role in ensuring the continuity of the right to education and in supporting the overall well-being of the student. It constitutes an educational and relational space integrated into the care pathway, offering the child the opportunity to maintain his or her role as a student and exercise cognitive, affective and social skills in a protected context (Ricci, 2018). The teaching activity, calibrated according to the clinical condition, helps to build a bridge between the experience of the disease and everyday life, strengthening the perception of continuity and hope in the future (Zhu Winkel, 2014). Alongside the human and relational dimension, educational technologies are becoming increasingly important in the design of accessible, inclusive and personalized learning environments (Ghedin Mazzocut, 2017). In particular, virtual reality (VR) emerges as a promising resource to address

the specific educational needs of hospitalized students, offering immersive and interactive experiences capable of stimulating participation and motivation (Analyti et al., 2024; Dettori, Letteri, 2023; Chen et al., 2022). VR makes it possible to build engaging and adaptable digital environments, in which the student can continue to learn, explore and collaborate, overcoming the constraints of the healthcare context. In addition, it promotes the connection with the class to which they belong, promoting the relational dimension and facilitating school reintegration at the end of the hospitalization (Di Padova, 2023). For these environments to be truly effective, however, they must be designed within a solid and coherent pedagogical framework. Technology alone is not enough: it is essential to integrate digital devices with teaching approaches that take into account the cognitive, emotional and relational needs of the student (Assaad et al., 2018; Benigno et al., 2018). In this perspective, VR stands out for its ability to simultaneously activate multiple perceptual channels – visual, auditory, motor – offering a multisensory and highly customizable learning experience, which can promote the understanding and memorization of content. A further value of the use of VR lies in the possibility of stimulating and enhancing mental representations (*imagery*), i.e. those inner images that support the construction of meaning, symbolic processing and the transformation of experience (Barrett et al., 2025). Imagery, in contexts where direct experience is limited, can support the development of complex cognitive skills and contribute to the student's emotional self-regulation (Wilson et al., 2018; Benoit et al., 2019). In light of the critical issues hereby mentioned (Fig.1), this contribution focuses on the educational experience of hospitalized young people, with particular attention to the role of the School in the Hospital in promoting continuity, well-being and inclusion.

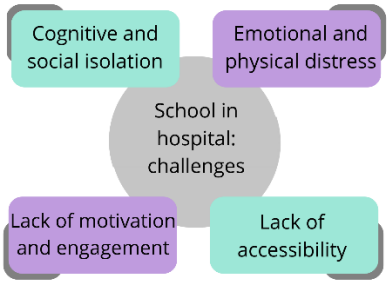

Figure 1. The challenges faced by the School in Hospital (SIH)

In this context, the transformative potential of virtual reality and the guided use of *imagery* as innovative pedagogical tools to support learning paths will be explored. Starting from the description of the SIH and its functions, the analysis will then extend to the theoretical references, to build a pedagogical framework capable of orienting an educational design centered on the complex needs of hospitalized students.

1. The School in the Hospital as an integrated educational space: continuity, inclusion and well-being

The School in the Hospital (SIH) is a unique educational environment, able to guarantee hospitalized students the right to continuous education, while contributing to their treatment path. In Italy the SIH is an institutionalized and active service at the national level, with 257 hospital sections and about 955 dedicated teachers (MIM, 2023), and is also recognized by the health sector as an integral part of the young patient's therapeutic project. From an organizational point of view, the SIH operates in close synergy with the hospital environment: A multidisciplinary approach involves teachers, doctors, psychologists and other professionals who collaborate as a team to globally support the sick student. This transdisciplinary collaboration makes it possible to consider the SIH not only as an educational service, but as a real educational opportunity, rooted in a bio-psycho-social care model and aimed at mitigating the condition of fragility and promoting the overall well-being of the child (Carnazzo et al., 2024). On a pedagogical level, the school in the hospital ensures the continuity of learning processes, preventing illness and hospitalization from abruptly interrupting the training course. Hospital teachers modulate and adapt teaching in a flexible and personalized way, taking into account the health conditions and individual needs of each hospitalized student (Faraoni, Melchiori, 2024). Unlike the ordinary school context, times, spaces and methodologies are rethought to respond to unforeseen situations and ensure effective learning, despite physical limitations or ongoing therapies. Innovative teaching approaches and inclusive strategies are adopted that aim not only at educational success, but also at supporting the emotional and relational dimension of students, often compromised by illness and the hospital context. In this context, technological tools play a key role: from digital teaching to hybrid virtual classrooms, they make it possible to maintain a constant connection with the school of origin, reducing social isolation and facilitating participation in school

activities even remotely (Faraoni, Melchiori, 2024). Such solutions have proven valuable in including hospitalized pupils in the learning community, preventing negative consequences such as the loss of school years or the risk of dropping out (Caggiano et al., 2021). In recent times, cutting-edge methodologies have been explored to strengthen school inclusion: for example, the use of avatars and virtual reality environments has been proposed to allow long-term students to interact with the class and maintain a sense of normality in educational relationships (Faraoni, Marsico, Piceci, 2023). The social and psychological aspects therefore play a central role within the SIH. The presence of the school in the hospital helps to preserve a sense of normality and belonging in sick children, helping them to maintain ties with peers and with their school identity (Caggiano et al., 2021). Several studies show that participation in hospital lessons has positive effects on students' emotional well-being, reducing anxiety, stress and even the perception of physical pain, thanks to the motivating and distracting power of school activities (Ciucci et al., 2024; Antonelli et al., 2019). The SIH represents, for the hospitalized student, a space where they are no longer just a patient, but can return to being, first of all, a student. This restores continuity with daily life interrupted by hospitalization and fosters a sense of agency and resilience (Hen, Gilan-Shochat, 2022; Kontogianni et al., 2021). To fully understand the potential of tools such as virtual reality in the SIH, it is necessary to resort to theoretical models capable of explaining how learning occurs through sensory, symbolic and relational integration.

2. Virtual reality as a support for education in the hospital

Virtual reality (VR) is quickly emerging as a powerful tool in education, offering new ways for students to interact with learning material. A recent meta-analysis showed, for example, that immersive VR significantly improves student learning compared to traditional learning techniques regardless of subject (Villena-Taranilla et al., 2022; Kuang et al., 2024). By creating immersive and interactive, multimedia and multimodal environments, VR has the potential to reshape the way we think about the lesson, offering greater accessibility to both contexts and content (Analyti et al., 2024) and thus putting the student's sense of control and agency at the center, with positive consequences on multiple aspects of learning, such as engagement, memorization and motivation. In this way, it can be configured as a powerful and useful tool not only for the psycho-physical well-being of the student

in the hospital context but also to ensure academic continuity and counteract dropouts. VR offers a unique and immersive approach to enhancing learning experiences by creating highly immersive environments that capture students' attention (Analyti et al., 2024) and that, by simulating real or imagined contexts, allow students to explore and interact with subjects in ways that traditional educational tools cannot match. The feeling of "being there" contributes to greater engagement (Johnson-Glenberg, 2018) and allows *learning by doing*, a factor considered in the literature as one of the greatest advantages of VR (Pirkkalainen et al., 2021). Virtual reality therefore provides the opportunity for learning that is both experiential and safe for the students in treatment, because it takes place in a protected and risk-free environment (Analyti et al., 2024). Immersiveness and the experiential element also allow embodiment, i.e. the integration of significant physical movement with the content to be learned; this element in turn positively affects the student's agency and sense of personal control over the learning environment (Johnson-Glenberg, 2018). Another relevant aspect, often mentioned in literature (Chen et al., 2022), is the possibility of greater personalization of learning, so as to make it more accessible and inclusive.

From this brief review of recent studies it emerges that the integration of VR in the hospital school is in line with constructivist learning theories, in which knowledge is actively constructed through experiential engagement rather than passively received. This suggests that the experiential nature of VR transcends disciplinary boundaries, making it particularly suited to the diverse educational needs of hospitalized children. VR in hospital education can provide valuable support because it tries to counteract some of the biggest challenges that hospitalized students face. For instances, immersiveness and interactivity can act positively on motivation, because with VR one can recreate environments and experiences that cannot otherwise be accessed. At the same time collaborative environments can be also created, counteracting isolation and encouraging the development of a sense of belonging. Finally, multimedia and multimodal environments and content, which allow different ways of using and accessing educational material, are also promoted within VR environments. All these potentialities have been showed in some experiences that some hospitals are already trying to put into practice, experiences that highlight the educational and therapeutic value of virtual reality for pediatric patients in various settings. Such experiences stressed that integrating VR also contributes to decreasing psychological and physiological stress because it provides a temporary escape from the hospital environment, creating

opportunities for emotional regulation and stress reduction during challenging medical situations, in addition to the possibility of maintaining academic continuity despite medical challenges. A noteworthy initiative in this area is the *Technology Laboratories for School in Hospital* program, launched in October 2019 at the Verona Hospital in Italy, a program that specifically targets hospitalized children by offering technology workshops focused on robotics and virtual reality with the aim of stimulating computational thinking and problem-solving skills, while promoting hope for the future among pediatric patients and their families, and maintaining crucial links with their normal academic environment despite hospitalization. The effectiveness of VR as an educational tool therefore goes beyond the simple acquisition of knowledge, but can bring numerous cognitive - including increased attention, strengthening of teamwork skills, critical thinking (Pellas et al., 2021; Kuang et al., 2024) - and affective-motivational benefits (Conrad, Kablitz, Schumann, 2024). These additional benefits are especially valuable for hospitalized children who may experience disruptions to their normal educational and social development.

3. Theoretical frameworks to support immersive learning in the SIO

The Double Code Theory

The *Double Code Theory*, developed by Allan Paivio (1971, 1986), argues that information is processed through two distinct but interconnected systems: one verbal and one visual. According to the author, learning is most effective when a concept is represented simultaneously in both modalities, since the two encodings activate separate cognitive pathways that reinforce each other (Clark Paivio, 1991). In an educational context such as a hospital, the combination of verbal and visual channels can prove to be strategic in compensating for the difficulties related to concentration and sensory deprivation that hospitalization can entail. Virtual reality, by offering immersive and multisensory environments, facilitates the dual encoding of information, promoting conceptual understanding and memorization. At the same time, the use of *imagery* allows the student to build mental representations that complement verbal narration, enhancing the effectiveness of learning even in the absence of external sensory stimuli.

The Multimedia Learning Theory

The *Multimedia Learning Theory*, developed by Richard Mayer (2001, 2009), is based on the idea that people learn more effectively through a combination of words and images, rather than just words. Mayer identifies two distinct cognitive channels – verbal and visual – each with limited capabilities, and emphasizes the importance of active processing by the student, who selects, organizes and integrates information to build a coherent mental model. Virtual reality represents an advanced form of multimedia, integrating dynamic visuals, narrative audio, and interactivity. However, to be truly effective, VR must be designed according to some key principles: that of coherence (eliminating irrelevant content), contiguity (spatial and temporal association between text and image) and control by the learner (Mayer, 2009). These precautions are particularly crucial in environments with a high cognitive load, such as hospitals, where learning must be intuitive and adaptable. In this context, imagery plays a complementary role, facilitating the transition from external visual representation (VR) to internal visual representation (imagery), and contributing to deeper conceptual processing.

Constructivism

Constructivism, in its main declinations of Piaget, Vygotskij and Bruner, conceives learning as an active process in which the subject builds knowledge starting from his own experiences, and this well explains the learning process favored by the use of VR. According to Piaget (1970), cognitive development is divided into successive evolutionary stages (sensorimotor, preoperative, concrete operative, formal operative), each characterized by specific modes of representation of reality and construction of knowledge. Virtual reality can provide a conducive environment to support the transition between these stages, offering exploratory experiences that stimulate assimilation and accommodation. According to Vygotsky (1978), cognitive development is influenced by the social and cultural environment and is realized in the zone of proximal development, through interaction with more competent adults or peers. Bruner (1966) emphasizes the role of representation in learning, articulating it on three levels: enactive (action), iconic (image), symbolic (language). Virtual reality is able to activate all three of these forms, allowing the student to explore, visualize, and reflect on concepts. In the hospital environment, where corporeality is often limited, virtual simulation can make up for physical action (enactive representation) and encourage the construction of knowledge through immersive experiences. In addition, virtual environments can be designed

to promote forms of collaboration, recreating social learning dynamics even at a distance. In this scenario, *imagery* becomes a valuable tool for keeping the symbolic and affective dimension of the educational experience alive: thanks to guided visualizations or imaginative narratives, the student is able to build personal and deep meanings, even in situations of isolation or physical limitation.
In the light of these theoretical frameworks, it is evident how the integrated use of virtual reality and mental representations can offer a significant contribution to the construction of personalized, multisensory and motivating educational environments. These premises take on an even more significant meaning if placed in the context of the School in the Hospital, where the right to learn is intertwined with complex clinical, emotional and relational needs. It is from these instances that the reflection on the specificity of this educational environment is developed, in order to explore how technology can support and enhance the educational path of hospitalized students.

4. Imagery as a learning strategy in immersive environments

In the field of education imagery represents a valuable tool to support learning, especially in situations where access to direct experiences is limited, difficult or impossible, such as hospital settings. In fact, imagery can be defined as the ability to create and manipulate mental representations of objects, events or situations, in their physical absence (Finke, 1989; Nanay 2017; 2018), thus maintaining a relationship of analogy and equivalence with external representations. It is a cognitive process that involves different sensory modalities – visual, auditory, kinaesthetic – and that can be spontaneous or intentionally stimulated for educational purposes (Antonietti, Colombo, 2011; Colombo, 2012; Seel, 2012). The main cognitive theories of learning converge in stating that the educational process is based on the construction and elaboration of mental representations and on the integration of stimuli from different channels (verbal and non-verbal, auditory and visual) (Paivio, 1986; Mayer, 2009; Ma, Ye, 2018; Liu et al., 2018). In this perspective, imagery can be considered a privileged tool for the creation of multimodal cognitive experiences even in the absence of concrete external stimuli. Therefore, the literature shows that mental images can promote the learning process in various respects (Eckhoff, Urbach, 2008; Clark and Lyons 2010), an assumption that embraces the idea that cognition is the result of mental representations generated from the systematic organization of information from

experience (Seel, 2003; 2017). Learning is conceived in this perspective as an imaginative and interactive process of construction of mental images (Clement, Rea-Ramirez, 2008) to arrive at a better understanding of the subject, to develop cognitive, linguistic, visual-spatial (Kedra, 2018), logical and problem-solving skills (Antonietti and Colombo 2011). Images, thanks to the analogical correspondence with the topics to be learned or with the problems to be solved, allow one to anticipate operations and physical changes, to reorganize the stored contents so as to grasp new elements or reinterpret them. Precisely for this reason, in the context of Virtual Reality (VR), imagery finds a particularly fertile ground. VR, in fact, not only stimulates the creation of mental images through immersive environments, but also allows to actively guide and model the user's imaginative experience, so that it is consistent with the training objectives. Therefore, teaching strategies based on imagery are synergistic with respect to the factors that influence the meaningfulness of the educational experience already illustrated in the previous chapters, such as: interest and intrinsic motivation - since the possibility of mentally "seeing" what is being learned generates a more engaging and rewarding experience; self-efficacy, as the imagination of oneself in the act of successfully performing a task improves the perception of competence and the aptitude for learning; self-regulation, inasmuch as the use of imaginative techniques allows greater awareness of one's mental states and better management of learning; and finally embodiment, considering that imagery can stimulate forms of cognitive embodiment, favouring the integration between body and mind, central in clinical contexts (Fig. 2).

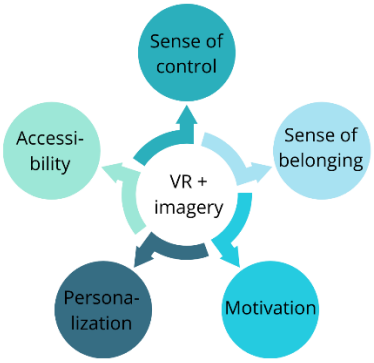

Figure 2. The potentialities offered by the interplay between virtual reality and imagery in educational settings

Therefore, the integration of imagery in education in immersive VR contexts, especially in hospitals, makes it possible to combine the power of digital simulation with the effectiveness of mental representations. In this way, forms of active, immersive and transformative learning are possible, even in contexts where physical, emotional or logistical conditions place significant constraints on direct experience.

5. The interplay between imagery and VR for schools in hospitals: A pedagogical model

In light of the challenges that school in hospitals entails - isolation, difficulty in accessing complete educational experiences, loss of motivation and often complex emotional conditions - the need for a pedagogical model capable of addressing these needs in an integrated way emerges. In this context, building upon existing models, such as the *Cognitive Affective Model of Immersive Learning* (CAMIL) (Makransky & Petersen, 2021), that stress the important of multifactorial perspectives, we propose an approach that combines Virtual Reality (VR) and imagery as synergistic tools to support student learning in a hospital environment. VR offers immersive and interactive experiences that can recreate otherwise inaccessible educational environments and situations and immersion allows for active student involvement, stimulating motivation and a sense of presence. At the same time, imagery - i.e. the ability to mentally evoke sensory or experiential images - allows the student to activate deep cognitive processes even in the absence of the real object. The two strategies, when combined, are mutually reinforcing, offering both an external immersive experience and an internal and personal reworking of the content. The integrated model is divided into four key components, each of which aims to respond to specific educational, emotional and cognitive needs of hospitalized students, namely an affective, a motivational, a cognitive and finally a collaborative component. The first element of the model concerns emotional support and the creation of a sense of belonging, recreating familiar and reassuring virtual environments to reduce anxiety and a sense of isolation; imagery in this sense can contribute to an improvement in emotional regulation, as an individual's ability to generate positive mental images can predict positive affective responses (Wilson et al. 2018; Benoit et al. 2019) and thereby strengthen psychological well-being. The second component is motivational, as motivation turns out to be another challenging factor in hospital education

contexts: VR and imagery, thanks to their high degree of involvement, can rekindle interest in learning, stimulating curiosity and the desire to explore, while imagery activates imagination and personal participation, making the student the protagonist of his or her own educational process.
Furthermore, aligning with the theories of *multimedia learning* and *double code* that highlight how the presentation of content in visual and verbal form promotes greater understanding and memorization, the multimedia nature of VR and imagery allows to intervene directly on the comprehension and recall of content, thus covering the cognitive component of the learning-teaching path. Finally, school in the hospital must not give up the value of peer relationships, as isolation is one of the factors that contributes to poor success and school dropout by students in hospital. Shared virtual environments can facilitate interaction and collaboration between students, even remotely, thus ensuring educational and social continuity. In these contexts, imagery can also be used in a cooperative key, for shared storytelling activities, imaginative problem solving and virtual role-playing. The integrated VR + imagery model offers a concrete and structured response to the challenges of school in hospital. It is not just a technological proposal, but a real pedagogical vision, based on solid theoretical references and a deep understanding of the needs of students in unconventional educational contexts. From this point of view, VR and imagery are not substitute tools for the educational relationship, but powerful resources to enrich it, personalize it and make it accessible, even in the most vulnerable contexts.

Conclusions

This research aimed to explore the intersection of hospital education (school in hospital), imagination and virtual reality (VR) as tools to foster engaging and meaningful learning experiences for hospitalized pupils (Fig. 3). Integrating these three domains has the potential to transform hospital education, offering cognitive and emotional benefits that go beyond traditional methods. For VR-based learning environments to be effective, their design must be based on a solid pedagogical framework. Based on existing literature, theoretical perspectives - such as *Double-Code Theory*, *Multimedia Learning Theory* and *Constructivism* - and practical applications, an integrated pedagogical approach combining VR and images was therefore proposed. This approach takes into account four key components – affective, cognitive, motivational and collaborative – to promote immersive and

personalized learning experiences. The affective component focuses on the use of VR and imagery techniques to evoke positive emotions and foster a sense of belonging.

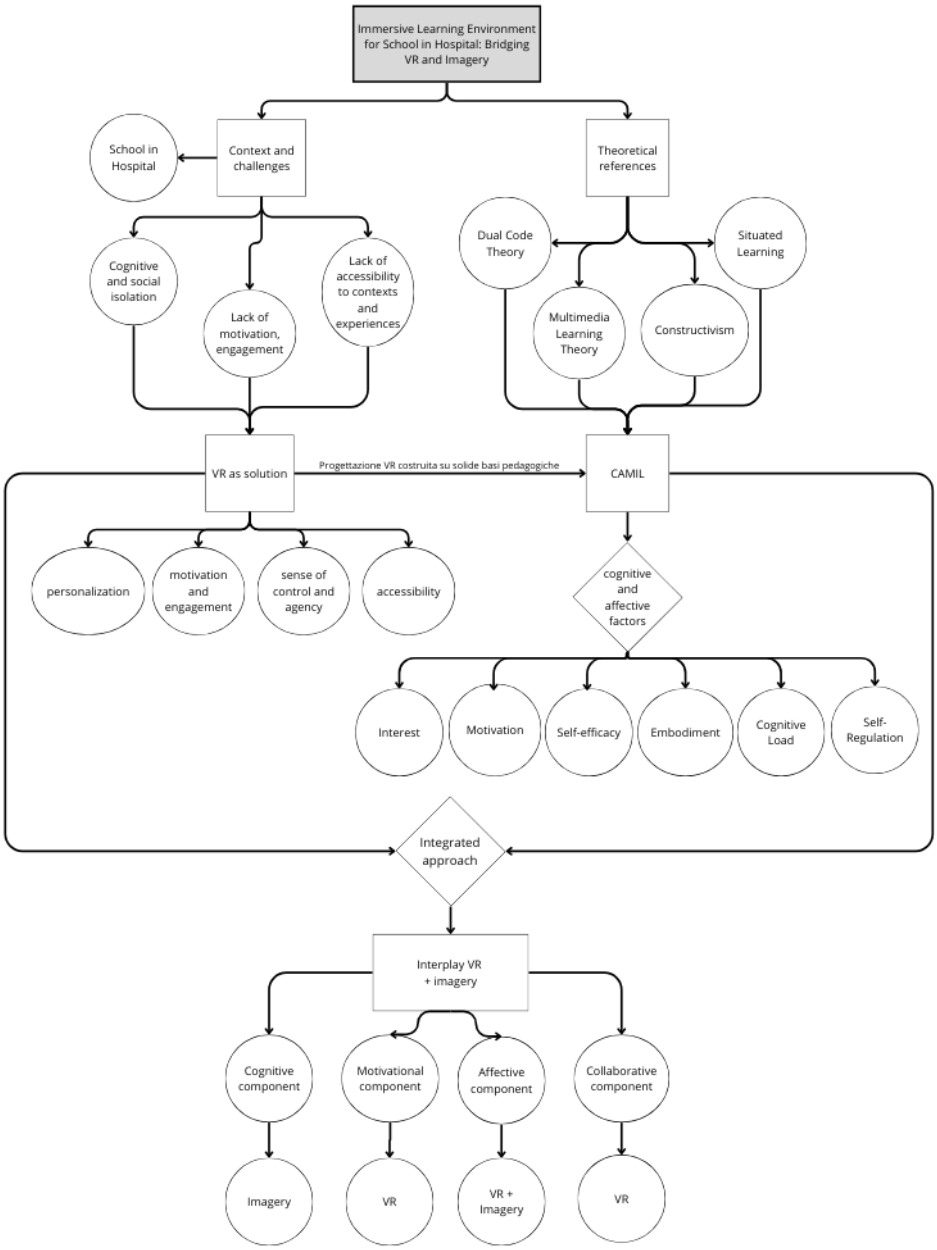

Figure 3. An integrated schema of the proposed framework

The cognitive component aims to improve learning through multisensory and interactive experiences, reducing cognitive load and fostering deep understanding. The motivational component emphasizes the role of engaging and personalized experiences to increase student engagement and perseverance. Finally, the collaborative component, enabled by VR, helps to overcome social isolation by fostering interaction and shared experiences between students. By adopting this integrated pedagogical perspective, it is possible to address the unique challenges of School in Hospital, providing hospitalized students with enriching, engaging, and inclusive learning opportunities.

Author contributions

The article is a joint work between the authors. For the writing of the paragraphs, Elisabetta Faraoni took care of §1 and §3; Maria Vittoria Battaglia took care of §2 and §4; Together they wrote §5, Introduction and Conclusion.

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