IMMERSIVE LEARNING ENVIRONMENTS FOR INCLUSION: AN EXPLORATORY STUDY ON THE PERCEPTIONS OF IN-SERVICE TEACHERS

Tommaso Santilli[1]
University of Macerata
t.santilli1@unimc.it

Catia Giaconi
University of Macerata
catia.giaconi@unimc.it

Noemi Del Bianco
University of Macerata
n.delbianco@unimc.it

Ilaria D'Angelo
University of Macerata
i.dangelo@unimc.it

Double Blind Peer Review

Citation
Santilli, T., Giaconi, C., Del Bianco, N., & D'Angelo, I. (2026). Immersive learning environments for inclusion: An exploratory study on the perceptions of in-service teachers. *Italian Journal of Health Education, Sport and Inclusive Didactics, 10*(4).

Doi: https://doi.org/10.32043/gsd.v10i4.1851

Copyright notice:
© 2023 this is an open access, peer-reviewed article published by Open Journal System and distributed under the terms of the Creative Commons Attribution 4.0 International, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

gsdjournal.it
ISSN: 3103-5744

ABSTRACT
This study examines the perceptions of in-service teachers regarding the potential of immersive educational technologies, with a specific focus on immersive classrooms in inclusive settings. Framed within Special Pedagogy principles and the debate on Innovative Learning Environments, the research adopts a quantitative design with descriptive and exploratory data analysis to investigate participants' perceptions following a direct immersive experience in an immersive classroom. In the dynamic intersection between positive evaluations of educational value and persistent uncertainties related to practical implementation, this contribution explores the challenges of supporting teachers' professional development and reinforcing their inclusive agency, emphasising the importance of pedagogically grounded approaches to the adoption of immersive technologies as tools for participation, inclusion, and meaningful learning.

KEYWORDS
Special pedagogy; immersive educational technologies; teacher training.

Received 2026-07-08
Accepted 2026-10-27
Published 2026-10-30

[1] Tommaso Santilli contributed to the writing of Sections 3, 4, and 5. Catia Giaconi, Noemi Del Bianco, and Ilaria D'Angelo contributed to the writing of Sections 1, 2, and 6.

1. Introduction

The social, cultural, and technological changes currently affecting educational systems highlight how teaching and learning processes are increasingly shaped by the integration of technological devices into educational practice (Borsini & Giaconi, 2025; Fischer et al., 2022; Giaconi et al., 2018; Hankey et al., 2017; Pinnelli & Fiorucci, 2019, 2020; Potestio, 2022). Such transformations are redefining learning environments as dynamic spaces in which pedagogical and relational dimensions intersect, with particular emphasis on accessibility and inclusion (Campitiello et al., 2023; d'Alonzo & Giaconi, 2024; Giaconi et al., 2023). In this direction, recent advances in Information and Communication Technologies (ICT) and eXtended Reality (XR), are supporting educational innovation through the reconfiguration of the very spaces in which teaching and learning processes take place (Boeskens & Meyer, 2025; Guo et al., 2021; Ministero dell'Istruzione e del Merito, 2022; OECD, 2013).

Building on these considerations, the concept of Innovative Learning Environments (ILEs) has emerged as a key framework for rethinking the role of educational spaces by leveraging the transformative potential of educational technologies (Alnagrat et al., 2022; Caldarelli et al., 2023; Campitiello et al., 2023). Within this perspective, immersive classrooms, based on the integration of physical environments and multisensory digital content, can be understood as advanced ILEs capable of expanding access to learning content, fostering experiential learning, and enhancing engagement across diverse educational contexts (Bocci et al., 2021; Donally, 2021; Sharrab et al., 2023). However, these environments should not be interpreted solely from a technological perspective. Rather, they should be understood as complex ecosystems in which pedagogical design and the use of technology are inextricably intertwined, requiring new forms of professional knowledge and expertise

(Borsini & Giaconi, 2025; D'Angelo et al., 2024; Giaconi & Del Bianco, 2018; Rutten & Brouwer-Truijen, 2025). In this respect, the quality of learning environments is closely related to their capacity to promote accessibility and participation for all learners through teachers' inclusive agency (d'Alonzo & Giaconi, 2024; Giaconi et al., 2020; Giaconi et al., 2025).

Within this framework, the literature consistently recognises the importance of continuing professional development, not only for acquiring new knowledge and competencies, but also for fostering greater awareness and critical reflection (Aiello & Giaconi, 2024; De Mutiis & Amatori, 2023; Gulisano, 2023; Potestio, 2022), adopting reflective practices and developing the digital literacies required to support inclusive education (Borsini & Giaconi, 2025; Giaconi et al., 2025; Rutten & Brouwer-Truijen, 2025; Sánchez-Cruzado et al., 2021).

As the transformation of educational spaces appears to entail the redefinition of teachers' professional identities and practices, it becomes essential to understand how teachers perceive these emerging learning environments and the extent to which they feel prepared to integrate them into their practice. Against this background, and in line with previous research (Borsini & Giaconi, 2025; Caldarelli et al., 2023), the present study investigates the perceptions of a group of in-service teachers enrolled in a Specialisation Course for Support Teachers regarding the use of immersive classrooms as Innovative Learning Environments (ILEs). More specifically, it explores their perceptions of the educational and inclusive potential of immersive classrooms, as well as their perceived implications for inclusive instructional design and professional development. In doing so, the study seeks to identify both opportunities and

challenges associated with the integration of immersive learning environments into teaching practices, thereby contributing to the ongoing debate on educational innovation and inclusion.

2. Research background

As anticipated in the introduction, recent technological advances have created new opportunities for creating Innovative Learning Environments (ILEs) (OECD, 2013; UN, 2015), capable of reshaping "the different components, partnerships, and principles that are integral to learning environments." (OECD, 2013, p. 13). The growing diffusion of XR technologies in educational settings has consequently stimulated an increasingly significant body of research aimed at investigating how these technologies can both contribute to the design of inclusive learning environments and redefine the ways in which learners participate in teaching and learning processes (Aiello & Giaconi, 2024; Giaconi et al., 2023; Makransky & Petersen, 2021; Morganti & Riva, 2006; Radianti et al., 2020).

More specifically, XR technologies encompass a broad range of technological solutions capable of integrating the physical world with digital content through different levels of immersion (Slater et al., 1996; Slater et al., 2009), interactivity (Wang et al., 2021), and user interaction (Birt & Vasilevski, 2021), thereby creating hybrid learning experiences (Alnagrat et al., 2022; Kosko et al., 2021; Murala & Panda, 2023; Panda et al., 2022). As a result, these technologies enable multimodal access to educational content through flexible and adaptable learning configurations (Akçayir & Akçayir, 2017; Dhaas, 2024; Lester & Hofmann, 2020; Wellner et al., 1993).

Examining the current state of research on immersive classrooms, it is possible to note how existing studies are predominantly characterised by applied research, typically conducted on a small scale and based on short-term experimental protocols (Fogt & Heintzelman, 2024; Liu et al., 2020; Lorenzo et al., 2016). These studies have mainly focused on the development of interventions aimed at fostering the acquisition of specific skills within immersive environments and on the evaluation of users' experiences (Fogt & Heintzelman, 2024; Liu et al., 2020; Lorenzo et al., 2016). At a more descriptive level, research has also addressed the definition of design models for the development of immersive learning environments (Donally, 2021; Radianti et al., 2020; Sharrab et al., 2023). However, considerably less attention has been devoted to the development of pedagogical frameworks capable of supporting the inclusion of students with disabilities and Special Educational Needs (SEN) (Creed et al., 2023a, 2023b; Dudley et al., 2023).

This scenario highlights the need to frame immersive learning environments within inclusive principles, addressing teachers' ability to interpret their educational potential and mediate its use in a pedagogically informed and reflective manner (Caldarelli et al., 2023; Giaconi et al., 2023; Haleem et al., 2022; Muscarà & Messina, 2014; Pinnelli & Fiorucci, 2020). Previous studies have shown that teachers' sense of self-efficacy, their perceptions of the educational benefits of immersive technologies, and their interest in using such tools plays a central role in the effective implementation of educational technologies (Joo et al., 2018; Lemon & Garvis, 2016; Muscarà & Messina, 2014), impacting dimensions like sustainability, inclusion, and quality education.

In line with the research priorities of didactics and special pedagogy (Caldarelli et al., 2023; D'Angelo et al., 2024; Giaconi & Del Bianco, 2018; Giaconi et al., 2023; Giaconi et al., 2025; Pinnelli & Fiorucci, 2020), investigating teachers' perceptions of immersive classrooms as innovative learning environments represents a crucial step towards promoting inclusive technological innovation in school settings. By exploring how teachers perceive the educational potential of these environments and the challenges associated with their implementation, it becomes possible to generate evidence capable of informing the design of targeted training initiatives and pedagogical frameworks that support the effective integration of immersive technologies into inclusive educational practice.

3. Materials & methods

A quantitative study was conducted to explore teachers' perceptions of immersive classrooms as Innovative Learning Environments (ILEs). The study involved 86 in-service teachers and took place within the I.D.E.A. 360 immersive classroom, located at the Department of Education, Cultural Heritage and Tourism of the University of Macerata.

The research protocol consisted of three phases: introduction to the study; direct experience within the immersive classroom; data collection. During the immersive experience, participants, organised into small groups, interacted with three different educational scenarios. These included an interactive environment based on touch-responsive visual elements, an immersive storytelling experience integrating narration, visual animations, and soundscapes, and a music-based activity allowing participants to generate sounds through interaction with projected content.

Data were collected through a structured questionnaire composed of 20 items organised into four sections, which was developed ad hoc for the purposes of the study (Table 1). The first section aimed at collecting demographic and professional information, including gender, age, years of teaching experience and perceived digital competence. The three following sections aimed at collecting information regarding participants' personal experience within the immersive classroom, perceptions of immersive technologies for inclusive teaching, and perceived impact on future professional development.

Table 1: Questionnaire structure and items

Section	**Items**	**Response format**
Section 1: Demographic and professional information	Gender	Multiple choice (Male; Female; Prefer not to specify)
	Age	Multiple choice (20–30 years; 31–40 years; 41–50 years; Over 50 years)
	Years of teaching experience (including temporary/substitute teaching)	Short answer (indication in numbers)
	Self-perceived level of digital competence	Multiple choice (Basic; Intermediate; Advanced)
Section 2: Personal experience in the immersive classroom	The experience in the immersive classroom stimulated my professional curiosity	5-point Likert scale, where 1 corresponds to "Strongly disagree" and 5 to "Strongly agree"

	The visit increased my desire to further explore the use of immersive technologies in teaching.	
	I found the virtual environment and the technology presented extremely attractive and engaging.	
	I believe that the immersive experience offers added value compared with traditional forms of content delivery.	
	The experience stimulated me positively from an emotional perspective.	
	During the visit, I felt completely immersed in the environment, losing awareness of the external context.	
Section 3: Use of immersive technologies in the classroom and inclusion	I believe that immersive environments would allow me to offer a greater variety of activities to my students.	5-point Likert scale, where 1 corresponds to “Strongly disagree” and 5 to “Strongly agree”
	Immersive environments are effective tools for enhancing the engagement	

	and participation of students with Special Educational Needs (SEN).	
	I believe that this technology can facilitate access to educational content for students with different disabilities.	
	The use of the immersive classroom would help me personalise teaching according to the needs of individual students.	
	The availability of technical support and specific training is essential for my future use of these environments.	
Section 4: Impact on future teaching practice	I believe that I can acquire the competencies necessary to regularly integrate immersive technologies into my lessons.	5-point Likert scale, where 1 corresponds to “Strongly disagree” and 5 to “Strongly agree”
	e regular use of these technologies will increase my effectiveness as a support teacher.	
	Integrating the immersive classroom will make my teaching more stimulating and satisfying.	
	I am interested in participating in future training seminars or research projects on the use of immersive technologies.	

	I feel able to select the most appropriate immersive content for designing inclusive educational activities.	

Data analysis combined descriptive statistics and exploratory analyses aimed at identifying recurring patterns and relationships among the investigated variables (Siedlecki, 2020). No overall questionnaire score was calculated. For the descriptive analysis, responses to each Likert item were analysed individually by calculating the frequency and percentage distribution across the five response categories. For the exploratory analyses, mean item scores were calculated within the subgroups defined by self-perceived digital competence and years of teaching experience and were used to compare response profiles across groups. Given the descriptive and exploratory nature of the study and the unequal size of the subgroups, these comparisons were interpreted descriptively rather than as inferential evidence.

4. Results

The final sample consisted of 86 in-service teachers. Female participants represented the majority of the sample (n = 77, 89.5%), while male participants accounted for 10.5% (n = 9). The sample was relatively young, with participants aged 20–30 years representing the largest group (n = 34, 39.5%), followed by those aged 41–50 years (30.2%), 31–40 years (20.9%), and over 50 years (9.3%). Most participants reported one to five years of teaching experience (n = 60, 69.8%), whereas 22.1% (n = 19) had between six and ten years of experience and only a small proportion had more than ten years of teaching experience (n = 7, 8.1%). Regarding self-perceived digital competence, the majority of

participants reported an intermediate level (n = 58, 67.4%), followed by advanced (n = 15, 17.4%) and basic (n = 13, 15.1%) levels. A detailed overview of the participants' demographic and professional characteristics is provided in Figure 1.



Figure 1: Demographic and professional information

With reference to the second section of the questionnaire, participants reported highly positive perceptions of their experience within the immersive classroom. Specifically, the experience was found to stimulate professional curiosity, with 65.1% of participants assigning the highest score (5) and 25.6% selecting score 4, resulting in more than 90% positive evaluations. A similarly favourable pattern emerged regarding participants' desire to further explore the use of immersive technologies in educational settings: 57.0% selected score 5 and 30.2% selected score 4, corresponding to 87.2% positive responses. The immersive environment was also perceived as highly attractive and engaging, with 57.0% of respondents assigning the highest score and 34.9% selecting score 4. Likewise, participants strongly recognised the added value of

immersive experiences compared to traditional content delivery, with 66.3% assigning score 5 and 29.1% assigning score 4. Overall, more than 95% of the sample acknowledged a significant added value associated with the immersive experience. Participants also reported positive emotional engagement, as reflected by the high proportion of responses corresponding to scores 5 (65.1%) and 4 (23.3%). Finally, the item concerning the sense of immersion showed the greatest variability among responses. Although almost half of the participants (48.8%) reported feeling completely immersed in the environment (score 5) and a further 30.2% selected score 4, higher proportions of neutral (12.8%) and negative responses (8.1% score 2) were observed compared with the other items.

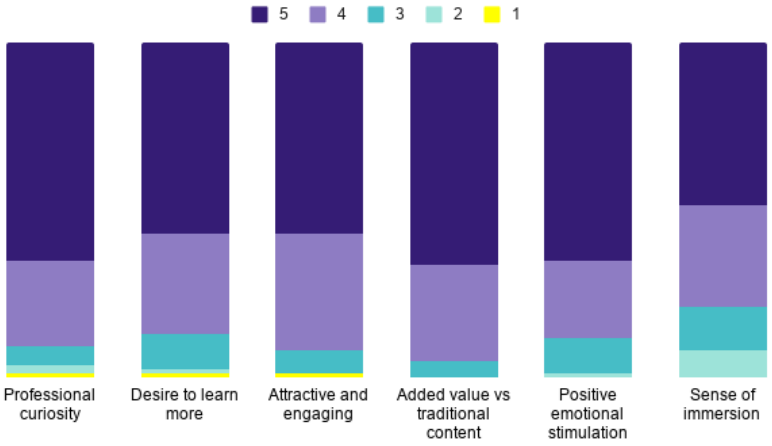


Figure 2: Personal experience within the immersive classroom

The results of the third section of the questionnaire reveal highly positive perceptions regarding the potential of immersive technologies, and immersive classrooms in particular, for supporting teaching practices and inclusive educational processes. Concerning the possibility of offering a greater variety of learning activities, most participants expressed favourable opinions, with 65.1% assigning the highest score (5) and 25.6% selecting score 4, resulting in

more than 90% positive responses. Similarly, participants strongly recognised the effectiveness of immersive technologies in enhancing the engagement and participation of students with Special Educational Needs: 68.6% assigned the highest score and 24.4% selected score 4, corresponding to 93.0% positive responses overall. A comparable pattern emerged regarding the perceived capacity of immersive technologies to facilitate access to educational content for students with disabilities. In this case, 69.8% of participants selected the highest score and 23.3% selected score 4, resulting in 93.1% positive evaluations. Likewise, the potential of immersive classrooms to support the personalisation of teaching was positively perceived, with 64.0% assigning score 5 and 26.7% assigning score 4, corresponding to 90.7% positive responses. Finally, the item concerning the importance of technical support and specific training for the future implementation of immersive classrooms received the strongest level of agreement among all items: 83.7% of participants assigned the highest score, while a further 11.6% selected score 4, resulting in 95.3% agreement. Across all items, neutral and negative responses remained comparatively low.

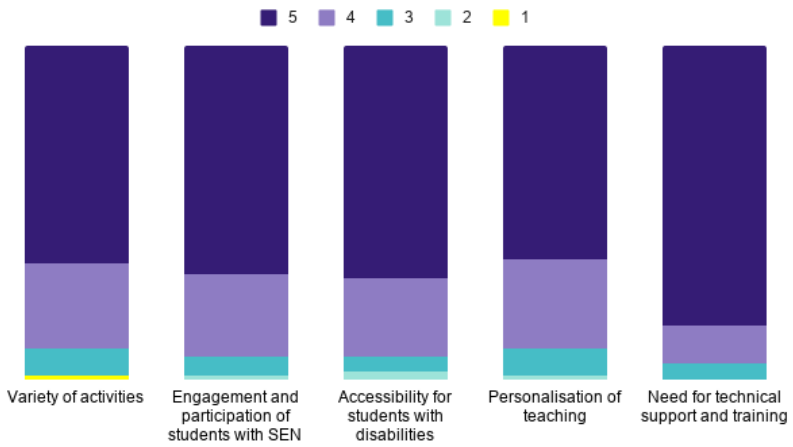


Figure 3: Perceptions of immersive technologies for inclusive teaching

The results of the fourth section of the questionnaire reveal generally positive perceptions regarding the potential impact of immersive technologies on participants' future professional development, although responses appear more nuanced than those observed in the previous sections. Concerning the possibility of acquiring the competencies necessary to regularly integrate immersive technologies into teaching practice, participants expressed a favourable outlook: 37.2% assigned the highest score (5) and 39.5% selected score 4, resulting in 76.7% positive evaluations overall. Nevertheless, a notable proportion of respondents selected the neutral option (16.3%), while 7.0% expressed negative evaluations (scores 1-2). A similarly positive trend emerged regarding the belief that the regular use of immersive technologies could enhance effectiveness as a support teacher. Specifically, 46.5% of participants assigned the highest score and 32.6% selected score 4, corresponding to 79.1% positive responses. However, 18.6% of the sample remained neutral. Higher levels of agreement were observed for the item exploring whether the integration of immersive classrooms could make teaching more stimulating and satisfying. In this case, 58.1% of participants assigned the highest score and 29.1% selected score 4, resulting in 87.2% positive responses. Similarly, strong interest emerged regarding future training opportunities and research initiatives related to immersive technologies. Indeed, 62.8% of respondents selected the highest score and 25.6% selected score 4, corresponding to 88.4% positive responses overall. Unlike the other items, perceptions concerning participants' ability to independently select the most appropriate immersive content for inclusive educational activities were more heterogeneous. While 31.4% assigned the highest score and 27.9% selected score 4, a substantial proportion of respondents selected the neutral option (27.9%). Furthermore, 12.8% expressed negative evaluations (scores 1-2).

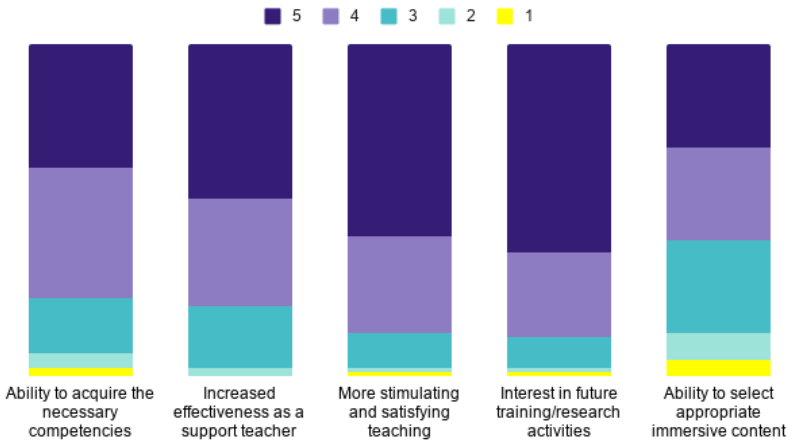


Figure 4: Perceived impact on future professional development

To explore whether participants' perceptions varied according to their professional profile, an exploratory analysis was conducted considering self-perceived digital competence and teaching experience. Mean scores were calculated for each questionnaire item and compared across groups.

With regard to digital competence, differences between groups were observed across the three questionnaire sections. Participants reporting intermediate digital competence consistently recorded the highest mean scores in relation to personal experience within the immersive classroom (Section 2: M = 4.56) and perceptions of immersive technologies for teaching and inclusion (Section 3: M = 4.66), while participants with basic competence reported lower evaluations (M = 4.12 and M = 4.37, respectively). A similar pattern emerged in Section 4, focusing on future professional development. Here, participants with intermediate digital competence again reported the highest scores (M = 4.34), followed by those with advanced competence (M = 4.27), whereas participants with basic competence expressed lower levels of confidence (M = 3.91). Figure 5 summarises response patterns according to participants' perceived digital competence. Teaching experience revealed a different pattern, as illustrated in

Figure 6. Participants with one to five years of experience reported the highest scores across all questionnaire sections (Section 2: M = 4.49; Section 3: M = 4.63; Section 4: M = 4.30). Teachers with six to ten years of experience showed slightly lower evaluations (M = 4.33, M = 4.39, and M = 4.15, respectively), while participants with more than ten years of experience displayed intermediate values. However, differences across experience groups remained relatively small, with score variations generally below 0.25 points on the Likert scale.

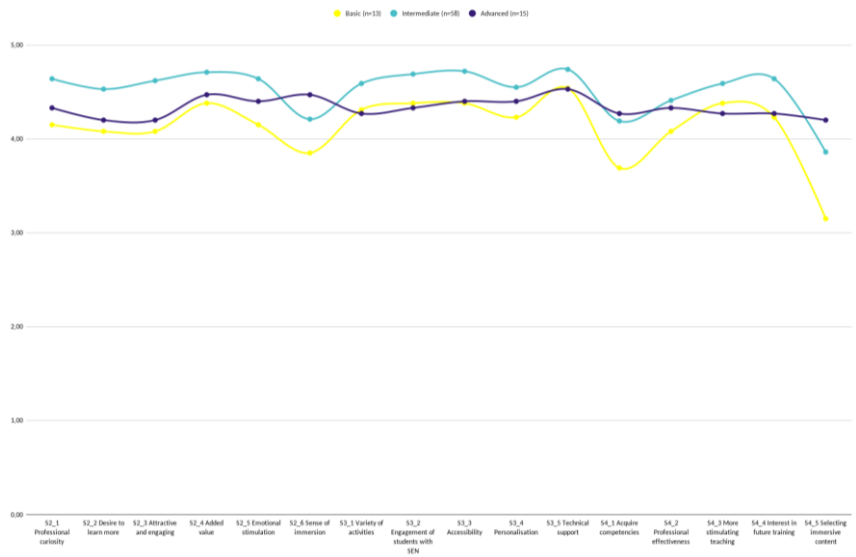


Figure 5: Differences in answers according to perceived digital competence

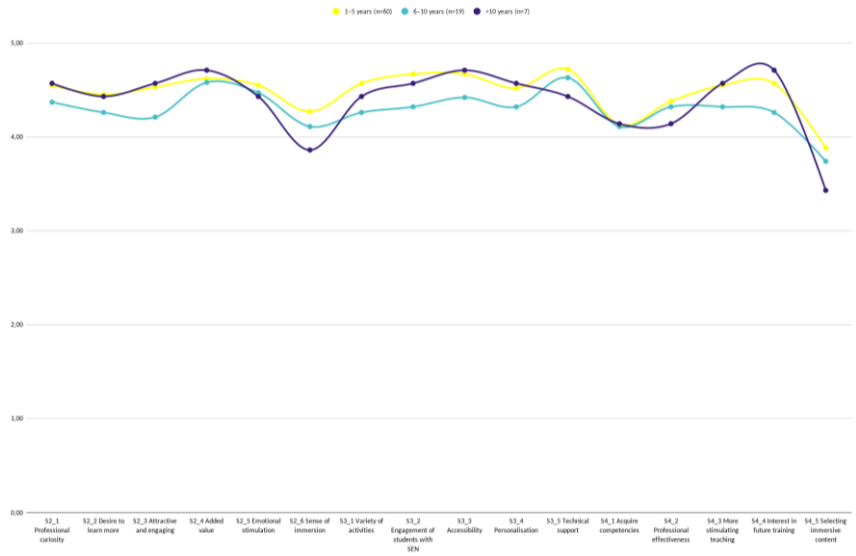


Figure 6: Differences in answers according to years of teaching experience

5. Discussion

Overall, the findings provide a positive picture of in-service teachers' perceptions of immersive classrooms, while highlighting the need to strengthen the professional competencies required for their effective pedagogical integration. The sample was characterised by a predominance of early-career teachers with intermediate levels of digital competence.

Participants consistently reported high levels of interest and appreciation for the immersive experience, particularly in terms of engagement, emotional stimulation, and perceived educational value. The highest levels of agreement concerned the added value of immersive technologies compared with traditional approaches, suggesting that teachers recognise their potential to enrich learning environments through the integration of multiple forms of representation, interaction, and expression (Campos et al., 2022; Fugate et al., 2025; Heintz et al., 2021). More broadly, the findings support the idea that

multimodal and flexible learning environments can enhance engagement and participation by offering multiple pathways for accessing and interacting with educational content (Murala & Panda, 2023; Slater et al., 1996). At the same time, perceptions of the sense of immersion were slightly more heterogeneous than those observed for the other items. This variability may be associated with both the characteristics of the immersive classroom itself – which provides a different type of experience compared with head-mounted systems – and the experimental conditions adopted in the study, where participants explored the environment in relatively large groups.

With regard to the integration of immersive technologies into classroom practice and their contribution to inclusive education, the findings reveal a broadly shared recognition of their educational potential. Participants consistently perceived immersive classrooms as valuable tools for increasing the variety of learning activities, promoting participation, facilitating access to educational content, and supporting the personalisation of teaching. Overall, these findings suggest that teachers recognise immersive classrooms as learning environments capable of addressing diversity through multiple forms of representation, engagement, and expression, in line with the principles of Universal Design for Learning (UDL) (Gill et al., 2024; Rose & Meyer, 2002). At the same time, the strongest level of agreement was observed for the need for technical support and specialised training, indicating that teachers consider the successful implementation of immersive technologies to depend not only on the availability of technological resources but also on the development of appropriate pedagogical and professional competencies. These findings reinforce the importance of sustained professional development to enable

teachers to integrate immersive technologies into meaningful inclusive educational practice (Caldarelli et al., 2023; Campitiello et al., 2023; Pinnelli & Fiorucci, 2019, 2020).

The findings concerning the perceived impact of immersive technologies on participants' future professional development reveal a more nuanced picture. Although respondents recognised the potential of immersive classrooms to make teaching more stimulating, increase professional effectiveness, and encourage participation in future training and research initiatives, they expressed lower levels of confidence in their ability to independently select and design appropriate immersive content for inclusive educational activities. This suggests that teachers distinguish between recognising the educational value of immersive technologies and possessing the practical competencies required to implement them effectively. Rather than reflecting resistance to innovation, this finding points to a specific need for pedagogically oriented professional development aimed at supporting teachers' know-how and digital skills (Aiello & Giaconi, 2024; Romano & Muscarà, 2023; Schön, 1983).

The exploratory analysis based on self-perceived digital competence provides further insight into these findings. Differences between groups remained relatively limited with respect to participants' perceptions of the immersive experience and the educational potential of immersive classrooms, becoming more evident only for the items related to future professional development. In particular, the lowest scores across all competence groups concerned participants' confidence in selecting appropriate immersive content for inclusive educational activities. These findings suggest that digital competence primarily influences teachers' perceived readiness to integrate immersive technologies into their professional practice rather than their recognition of the educational value of these environments. At the same time, the persistence of

uncertainty even among participants reporting advanced digital competence indicates that effective implementation depends not only on individual technological skills, but also on pedagogical knowledge and opportunities for targeted professional development. This interpretation is consistent with previous research highlighting that sustained training and instructional support are essential for fostering teachers' confidence (Meccawy, 2023). With reference to teaching experience, although participants with one to five years of experience generally reported the highest mean scores, differences between experience groups remained relatively modest and no progressive decline in perceptions was observed as professional experience increased. Rather than indicating substantially different attitudes towards immersive technologies, the findings suggest that positive perceptions are broadly shared among in-service teachers regardless of years of teaching experience. Overall, this suggests that teaching experience alone does not represent a major barrier to the adoption of immersive classrooms. Instead, the ability to translate positive attitudes into effective inclusive educational practice appears to depend more strongly on opportunities for professional learning than on either professional seniority or self-perceived technological competence. Nevertheless, these results should be interpreted cautiously, as the digital competence and teaching experience groups were characterised by unequal sample sizes. Consequently, the observed differences should be considered exploratory rather than conclusive.

Overall, the findings indicate that immersive technologies, and immersive classrooms in particular, are widely perceived by in-service teachers as promising resources for promoting educational innovation and inclusive teaching practices. At the same time, the transition from recognising their educational value to implementing them effectively in everyday teaching reveals a critical area in which specific professional development needs

emerge. Rather than reflecting resistance towards technological innovation, participants' responses suggest a need to strengthen the pedagogical competencies required to integrate immersive learning experiences into teaching practice. In this respect, professional development should extend beyond the acquisition of technical skills to foster teachers' inclusive and transformative agency (Aiello & Giaconi, 2024; Giaconi et al., 2025). Such a perspective is particularly relevant within the field of didactics and special pedagogy, which emphasises the situated and dynamic nature of inclusive teaching and highlights the importance of designing learning environments that respond to individual learner needs while recognising the influence of contextual and environmental factors on participation and learning (Aiello & Giaconi, 2024; d'Alonzo & Giaconi, 2024; Giaconi & Del Bianco, 2018; WHO, 2001).

6. Conclusions and future perspectives

The dialogue between special pedagogy and immersive technologies represents a dynamic and evolving field of inquiry, raising important challenges for the promotion of inclusive education through technological innovation. As consistently highlighted in the literature (Borsini & Giaconi, 2025; Masenya, 2021; Muscarà & Messina, 2014), the educational value of immersive technologies depends not simply on their availability, but on the development of pedagogically informed approaches that enable teachers to design meaningful, accessible, and inclusive learning experiences. In this respect, the findings of the present study reinforce the need to move beyond a technology-centred perspective and to support teachers in developing the competencies required to critically select, adapt, and integrate immersive resources within diverse educational contexts (De Mutiis & Amatori, 2023; Gulisano, 2023;

Pinnelli & Fiorucci, 2019, 2020; Potestio, 2022; Starkey, 2020). Such competencies are essential for ensuring that immersive classrooms become genuine Innovative Learning Environments rather than merely technologically enhanced spaces (Alférez-Pastor et al., 2023; Creed et al., 2023b; Freese et al., 2023; Nikou et al., 2024).

The findings of the present study confirm that the effective implementation of immersive classrooms requires processes of pedagogical appropriation and professional mediation, enabling teachers to reinterpret their professional role within rapidly evolving educational contexts. Rather than viewing immersive technologies as ends in themselves, teachers are called to adopt a proactive and reflective stance, combining technological innovation with professional agency to design learning experiences that are accessible, engaging, and truly inclusive (Aiello & Giaconi, 2024; Starkey, 2020). Consequently, the findings further highlight the importance of supporting educational innovation through structured professional development pathways that enable teachers to develop autonomous, informed, and reflective professional practices (Bocci et al., 2021; Donally, 2021; Potestio, 2022; Sharrab et al., 2023). In this perspective, professional learning can strengthen teachers' capacity to interpret ongoing technological change and to translate the educational potential of immersive technologies into meaningful classroom practice (De Mutiis & Amatori, 2023; Falloon, 2020; Gulisano, 2023; Starkey, 2020). In conclusion, supporting the transformation of teachers' professional practices becomes essential to ensuring that the ongoing evolution of educational environments translates into meaningful opportunities for participation, accessibility, and learning for all students.

References

Aiello, P., & Giaconi, C. (2024). *L'agire inclusivo. Interfacce pedagogiche e didattiche. Manuale per l'insegnante*. Morcelliana Scholé.

Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review*, *20*, 1–11. https://doi.org/10.1016/j.edurev.2016.11.002

Alférez-Pastor, M., Collado-Soler, R., Lérida-Ayala, V., Manzano-León, A., Aguilar-Parra, J. M., & Trigueros, R. (2023). Training digital competencies in future primary school teachers: A systematic review. *Education Sciences*, *13*(5), 461. https://doi.org/10.3390/educsci13050461

Alnagrat, A., Ismail, R. C., Idrus, S. Z. S., & Alfaqi, R. M. A. (2022). A review of extended reality (XR) technologies in the future of human education: Current trend and future opportunity. *Journal of Human Centered Technology*, *1*(2), 81–96. https://doi.org/10.11113/humentech.v1n2.27

Birt, J., & Vasilevski, N. (2021). Comparison of single and multiuser immersive mobile virtual reality usability in construction education. *Educational Technology & Society*, *24*(2), 93–106. https://www.j-ets.net/collection/published-issues/24_2.

Bocci, F., Guerini, I., & Travaglini, A. (2021). Le competenze dell'insegnante inclusivo. Riflessioni sulla formazione iniziale tra aspettative e conferme. *Form@re - Open Journal Per La Formazione in Rete*, *21*(1), 8–23. https://doi.org/10.13128/form-10463

Boeskens, L., & Meyer, K. (2025). Policies for the digital transformation of school education: Evidence from the Policy Survey on School Education in the Digital Age. *OECD Education Working* Papers, 328. OECD Publishing. https://doi.org/10.1787/464dab4d-en

Borsini, L., & Giaconi, C. (2025). New challenges for special pedagogy: A study on training teachers' perceptions of the role of AI. *Italian Journal of Special Education for Inclusion*, *13*(1), 34–46. https://doi.org/10.7346/sipes-01-2025-02

Caldarelli, A., D'Angelo, I., & Del Bianco, N. (2023). Digital inclusion: Le percezioni dei docenti di sostegno in formazione. In F. Peluso Cassese (Ed.), *Ricerche in neuroscienze educative* (pp. 158–159). Edizioni Universitarie Romane.

Campitiello, L., Caldarelli, A., Schiavo, F., Marras, A., & Di Tore, S. (2023). Augmented reality to promote cultural accessibility. *Journal of Inclusive Methodology and Technology in Learning and Teaching*, *3*(2). https://doi.org/10.32043/jimtlt.v3i2.98

Campos, E., Hidrogo, I., & Zavala, G. (2022). Impact of virtual reality use on the teaching and learning of vectors. *Frontiers in Education*, *7*, Article 965640. https://doi.org/10.3389/feduc.2022.965640

Creed, C., Al-Kalbani, M., Theil, A., Sarcar, S., & Williams, I. (2023a). Inclusive AR/VR: Accessibility barriers for immersive technologies. *Universal Access in the Information Society*, *23*(1), 59–73. https://doi.org/10.1007/s10209-023-00969-0

Creed, C., Al-Kalbani, M., Theil, A., Sarcar, S., & Williams, I. (2023b). Inclusive augmented and virtual reality: A research agenda. *International Journal of Human–Computer Interaction*, *40*(24), 6200–6219. https://doi.org/10.1080/10447318.2023.2247614

d'Alonzo, L., & Giaconi, C. (2024). *Manuale per l'inclusione*. Morcelliana Scholé.

D'Angelo, I., Santilli, T., Borsini, L., Del Bianco, N., & Giaconi, C. (2024). L'inclusione scolastica nella prospettiva europea: Riflessioni sulla formazione dei docenti/School inclusion in a European perspective: Reflections on teacher training. *Educrazia*, *1*, 18–30. https://educrazia.com/?page_id=131

De Mutiis, E., & Amatori, G. (2023). Per un professionista inclusivo: L'insegnante specializzato per il sostegno tra dimensioni formative e bisogni attesi. *Annali Online della Didattica e della Formazione Docente*, *15*(25), 58–79. https://doi.org/10.15160/2038-1034/2651.

Dhaas, A. (2024). Augmented reality in education: A review of learning outcomes and pedagogical implications. *American Journal of Computing and Engineering*, *7*(3), 1–18. https://doi.org/10.47672/ajce.2028

Donally, J. (2021). *The immersive classroom: Create customized learning experiences with AR/VR*. ASCD.

Dudley, J., Yin, L., Garaj, V., & Kristensson, P. O. (2023). Inclusive immersion: A review of efforts to improve accessibility in virtual reality, augmented reality and the metaverse. *Virtual Reality*, *27*(4), 2989–3020. https://doi.org/10.1007/s10055-023-00850-8

Falloon, G. (2020). From digital literacy to digital competence: The teacher digital competency (TDC) framework. *Educational Technology Research and Development*, *68*, 2449–2472. https://doi.org/10.1007/s11423-020-09767-4

Fischer, D., King, J., Rieckmann, M., Barth, M., Büssing, A., Hemmer, I., & Lindau-Bank, D. (2022). Teacher education for sustainable development: A review of an emerging research field. *Journal of Teacher Education*, *73*(5), 509–524. https://doi.org/10.1177/00224871221105784

Fogt, J. B., & Heintzelman, S. C. (2024). Social and Emotional Learning through Immersive Experiences for Students with Disabilities. *Immersive Learning Research - Practitioner*, *1*(1), 79–84. https://doi.org/10.56198/5M1RHFY7Q

Freese, M., Teichrew, A., Winkelmann, J., Erb, R., Ullrich, M., & Tremmel, M. (2023). Measuring teachers' competencies for a purposeful use of augmented reality experiments in physics lessons. *Frontiers in Education*, *8*, Article 1180266. https://doi.org/10.3389/feduc.2023.1180266

Fugate, J. M., Tonsager, M. J., & Macrine, S. L. (2025). Immersive extended reality (I-XR) in medical and nursing for skill competency and knowledge acquisition: A systematic review and implications for pedagogical practices. *Behavioral Sciences*, *15*(4), Article 468. https://doi.org/10.3390/bs15040468

Giaconi, C., Capellini, S. A., Del Bianco, N., Taddei, A., & D'Angelo, I. (2018). Study empowerment for inclusion. *Education Sciences & Society*, *9*(2), 166–183. https://journals.francoangeli.it/index.php/ess/article/view/7095

Giaconi, C., D'Angelo, I., Marcoionni, T., Santilli, T., & Borsini, L. (2025a). Teacher agency for inclusion: a study on the attitudes of pre-service support teachers. *The Australian Educational Researcher*, *52*, 4221–4242. https://doi.org/10.1007/s13384-025-00895-5.

Giaconi, C., D'Angelo, I., Marfoglia, A., & Gentilozzi, C. (2023). *Ecosistemi formativi inclusivi*. FrancoAngeli.

Giaconi, C., & Del Bianco, N. (2018). *Inclusione 3.0*. FrancoAngeli.

Giaconi, C., Del Bianco, N., D'Angelo, I., & Capellini, S. A. (2024). Il metodo di studio: Indagine esplorativa sulle percezioni di docenti in formazione. In A. Marfoglia & L. Borsini (Eds.), *La formazione inclusiva: Itinerari di pedagogia e didattica speciale* (pp. 7–30). Edizioni Accademiche Italiane.

Giaconi, C., Taddei, A., Del Bianco, N., Caldarelli, A., & D'Angelo, I. (2020). Dalla "voce degli studenti" alla co-progettazione di percorsi inclusivi: Uno studio di caso. *SIRD*, *2*, 186–193.

Gill, A., Irwin, D., Towey, D., Zhang, Y., Long, P., Sun, L., & Zheng, Y. (2024). Implementing universal design through augmented-reality game-based learning. *Computers & Education: X Reality*, *4*, Article 100070. https://doi.org/10.1016/j.cexr.2024.100070

Gulisano, D. (2023). Quale profilo per il docente inclusivo? Alcune risultanze di un'indagine esplorativa effettuata al Corso di Specializzazione per le Attività di Sostegno Didattico agli Alunni con Disabilità dell'Università degli Studi di Catania. *Annali Online della Didattica e della Formazione Docente*, *15*(25), 273–290. https://doi.org/10.15160/2038-1034/2664

Guo, X., Guo, Y., & Liu, Y. (2021). The development of extended reality in education: Inspiration from the research literature. *Sustainability*, *13*(24), Article 13776. https://doi.org/10.3390/su132413776

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, *3*, 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

Hankey, V. P., Price-Dennis, D., & Matthews, G. (2017). Continuous becoming: Moving toward mastery: Teacher education in the digital age. *The English Journal*, *106*(4), 97–100. http://www.jstor.org/stable/26359503.

Heintz, M., Law, E. L. C., & Andrade, P. (2021). Augmented reality as educational tool: Perceptions, challenges, and requirements from teachers. In n T. A. Majchrzak, J. Fromm, I. Wohlgenannt, & T. French (Eds.), *Technology-Enhanced Learning for a Free, Safe, and Sustainable World* (Lecture Notes in Computer Science, Vol. 12884) (pp. 315–319). Springer. https://doi.org/10.1007/978-3-030-86436-1_27

Joo, Y. J., Park, S., & Lim, E. (2018). Factors influencing preservice teachers' intention to use technology: TPACK, teacher self-efficacy, and technology acceptance model. *Journal of Educational Technology & Society*, *21*(3), 48–59.

Kosko, K. W., Ferdig, R. E., & Roche, L. (2021). Conceptualizing a shared definition and future directions for extended reality (XR) in teacher education. *Journal of Technology and Teacher Education*, *29*(2), 257–277. https://doi.org/10.70725/002527odhhrp

Lemon, N., & Garvis, S. (2016). Pre-service teacher self-efficacy in digital technology. *Teachers and Teaching*, *22*(3), 387–408. https://doi.org/10.1080/13540602.2015.1058594

Lester, S., & Hofmann, J. (2020). Some pedagogical observations on using augmented reality in a vocational practicum. *British Journal of Educational Technology*, *51*(3), 645–656. https://doi.org/10.1111/bjet.12901

Liu, R., Wang, L., Lei, J., Wang, Q., & Ren, Y. (2020). Effects of an immersive virtual reality-based classroom on students' learning performance in science lessons. *British Journal of Educational Technology*, *51*(6), 2034–2049. https://doi.org/10.1111/bjet.13028

Lorenzo, G., Lledó, A., Roig, R., Lorenzo, A., & Pomares, J. (2016). *New educational challenges and innovations: Students with disability in immersive learning environments*. In D. Cvetković (Ed.), *Virtual Learning*. InTech. https://doi.org/10.5772/65219

Makransky, G., & Petersen, G. B. (2021). The Cognitive Affective Model of Immersive Learning (CAMIL): A theoretical research-based model of learning in immersive virtual reality. *Educational Psychology Review*, *33*, 937–958. https://doi.org/10.1007/s10648-020-09586-2

Masenya, T. M. (2021). Digital literacy skills as prerequisite for teaching and learning in higher education institutions. *Mousaion: South African Journal of Information Studies*, *39*(2), 1–20. https://doi.org/10.25159/2663-659X/8428

Meccawy, M. (2023). Teachers' prospective attitudes towards the adoption of extended reality technologies in the classroom: Interests and concerns. *Smart Learning Environments*, *10*, Article 36. https://doi.org/10.1186/s40561-023-00256-8

Ministero dell'Istruzione e del Merito. (2022). *Piano Scuola 4.0. Decreto n. 161 del 14 giugno 2022*. https://www.mim.gov.it/documents/20182/6735034/PIANO_SCUOLA_4.0.pdf

Morganti, F., & Riva, G. (2006). *Conoscenza, comunicazione e tecnologia. Aspetti cognitivi della realtà virtuale*. Edizioni Universitarie LED.

Murala, D. K., & Panda, S. K. (2023). The role of immersive reality (AR/VR/MR/XR) in metaverse. In A. Chandrashekhar, S.H. Saheb, S.K. Panda, S. Balamurugan & S.-L. Peng (Eds.), *Metaverse and Immersive Technologies: An Introduction to Industrial, Business and Social Applications* (pp. 159–189). Wiley. https://doi.org/10.1002/9781394177165.ch6

Muscarà, M., & Messina, R. (2014). Percezione delle competenze e dell'utilità d'uso delle tecnologie in classe e modelli di formazione dei docenti. *Italian Journal of Educational Research*, *13*, 181–196. https://ojs.pensamultimedia.it/index.php/sird/article/download/1102/1068

Nikou, S. A., Perifanou, M., & Economides, A. A. (2024). Exploring teachers' competences to integrate augmented reality in education: Results from an international study. *TechTrends*, *68*(5), 1208–1221. https://doi.org/10.1007/s11528-024-01014-4

OECD. (2013). *Innovative learning environments*. OECD Publishing. https://doi.org/10.1787/9789264203488-en

Panda, B., Tripathy, N. K., Sahu, S., Behera, B. K., & Elhady, W. E. (2022). Controlling Remote Robots Based on Zidan's Quantum Computing Model. *Computers, Materials & Continua*, *73*(3), 6225-6236. https://doi.org/10.32604/cmc.2022.028394

Pinnelli, S., & Fiorucci, A. (2019). La pedagogia speciale incontra le tecnologie. In S. Besio & R. Caldin (Eds.), *La pedagogia speciale in dialogo con le altre discipline. Intersezioni, ibridazioni e alfabeti possibili* (pp. 257–274). Guerini Scientifica.

Pinnelli, S., & Fiorucci, A. (2020). Valutazione della componente tecnologica per la promozione dell'inclusione. Un'esperienza di ricerca-azione su base index rivolta a docenti di sostegno in formazione. *MeTis*, *10*(1), 257–278. https://www.metisjournal.it/index.php/metis/article/view/361

Potestio, A. (2022). La formazione continua per la professione docente. *Formazione Lavoro Persona*, *12*(37), 9–21. https://cqiiarivista.unibg.it/index.php/fpl/article/view/601

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications: Design elements, lessons learned, and research agenda. *Computers & Education*, *147*, Article 103778. https://doi.org/10.1016/j.compedu.2019.103778

Romano, A., & Muscarà, M. (2023). Pensarsi professionista. Esperienze narrative riflessive e ricognitive tra alcuni insegnanti della scuola dell'infanzia e primaria. *Educational Reflective Practices*, (1), 59–69. https://doi.org/10.3280/erp1-2023oa15878

Rose, D. H., & Meyer, A. (2002). *Teaching every student in the digital age: Universal design for learning*. ASCD.

Rutten, N., & Brouwer-Truijen, K. (2025). Defining XR-specific teacher competencies: Extending the DigCompEdu framework for immersive education. *Trends in Higher Education*, *4*(1), Article 11. https://doi.org/10.3390/higheredu4010011

Sánchez-Cruzado, C., Santiago Campión, R., & Sánchez-Compaña, M. T. (2021). Teacher digital literacy: The indisputable challenge after COVID-19. *Sustainability*, *13*(4), Article 1858. https://doi.org/10.3390/su13041858

Schön, D. A. (1983). *The reflective practitioner*. Basic Books.

Sharrab, Y. O., Almutiri, N. T., Tarawneh, M., Alzyoud, F., Al-Ghuwairi, A. R., & Al-Fraihat, D. (2023). Toward smart and immersive classroom based on AI, VR, and 6G. *International Journal of Emerging Technologies in Learning*, *18*(2), 4–16. https://doi.org/10.3991/ijet.v18i02.35997

Siedlecki, S. L. (2020). Understanding descriptive research designs and methods. *Clinical Nurse Specialist*, *34*(1), 8–12. https://doi.org/10.1097/NUR.0000000000000493

Slater, M., Linakis, V., Usoh, M., & Kooper, R. (1996). Immersion, presence and performance in virtual environments: An experiment with tri-dimensional chess. In *Proceedings of the ACM Symposium on Virtual Reality Software and Technology (VRST '96)* (pp. 163–172). Association for Computing Machinery. https://doi.org/10.1145/3304181.3304216

Slater, M., Lotto, B., Arnold, M. M., & Sanchez-Vives, M. V. (2009). How we experience immersive virtual environments: The concept of presence and its measurement. *Anuario de Psicología / The UB Journal of psychology*, *40*(2), 193–210. https://raco.cat/index.php/AnuarioPsicologia/article/view/143105

Starkey, L. (2020). A review of research exploring teacher preparation for the digital age. *Cambridge Journal of Education*, *50*(1), 37–56. https://doi.org/10.1080/0305764X.2019.1625867

UN. (2015). *Transforming our world: The 2030 agenda for sustainable development*. United Nations. https://sdgs.un.org/2030agenda

Wang, A., Thompson, M., Uz-Bilgin, C., & Klopfer, E. (2021). Authenticity, interactivity, and collaboration in virtual reality games: Best practices and lessons learned. *Frontiers in Virtual Reality*, *2*, Article 734083. https://doi.org/10.3389/frvir.2021.734083

Wellner, P., Mackay, W., & Gold, R. (1993). Computer-augmented environments: Back to the real world. *Communications of the ACM*, *36*(7), 24–26.

WHO. (2001). Interna*tional classification of functioning, disability and health (ICF)*. World Health Organization. https://www.who.int/standards/classifications/international-classification-of-functioning-disability-and-health