

Usability, Pedagogical Effectiveness, and Student Experience in a VR-Based Motor Skills Program for Special Educational Needs: Findings from an Erasmus+ Project

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ABSTRACT:

Motor skills are essential for children's educational development, facilitating literacy, executive functioning, attention, and social integration. For children with special educational needs (SEN), motor difficulties frequently co-occur with other neurodevelopmental challenges, exacerbating barriers to inclusive learning environments. In response to these challenges, this study assessed a virtual reality (VR) motor skills training program developed by the Erasmus+ project and implemented across Türkiye, Greece, Spain, and Poland. A quantitative, cross-sectional survey design was employed using data from educators and students involved in the project's training and implementation phases. Three instruments were used to collect data: a workshop evaluation scale completed by educators following professional development training, a teacher evaluation form administered after program implementation, and a student feedback form completed by SEN students. The findings indicate that educators generally perceived the training process and VR-based intervention positively, particularly regarding pedagogical value, student engagement, and support for motor development. However, concerns were raised about the relevance of certain training components and the technology's usability, especially its ease of use in classroom settings. Students reported high levels of enjoyment and engagement with the VR activities, suggesting strong acceptance of the intervention, although variations in self-confidence were noted. The results suggest that VR-based motor skills training holds significant promise as an engaging and pedagogically valuable tool for SEN education. Nevertheless, its effectiveness appears to depend on usability, contextual adaptation, and the quality of

implementation. Future research should incorporate objective motor performance measures and longitudinal designs to understand better the sustained impact of VR-based interventions in inclusive educational contexts.

Keywords: virtual reality, motor skills, special educational needs (SEN), inclusive education, pedagogical effectiveness.

1. Introduction

Motor skill development is a fundamental aspect of children's learning and development, extending beyond physical competence to influence cognitive function, academic achievement, and social participation. Fine motor skills, such as hand-eye coordination, manual dexterity, and graphomotor control, are closely linked to early literacy and writing proficiency, while gross motor skills, including balance, posture, and locomotion, facilitate embodied interaction with the environment and support exploratory learning processes (Cameron et al., 2012; Grissmer et al., 2010). Increasingly, research positions motor competencies not as peripheral abilities but as integral mechanisms underpinning executive functioning, attention regulation, and sustained engagement in learning tasks. From this perspective, motor development can be understood as a functional infrastructure that enables children to participate meaningfully in educational contexts. These dynamics are particularly pronounced in children with special educational needs (SEN), who often face persistent challenges in acquiring motor skills. Neurodevelopmental conditions, such as autism spectrum disorder (ASD), cerebral palsy, developmental coordination disorder, and intellectual disability, are frequently associated with impairments in motor planning, coordination, and proprioceptive processing (Fournier et al., 2010). Crucially, these motor difficulties rarely occur in isolation; rather, they interact with deficits in executive functioning, attention, and social communication, thereby generating compounded barriers to learning and participation (Piek et al., 2008). As highlighted in recent syntheses, motor impairments in SEN populations have multidimensional consequences, affecting not only academic performance but also independence in daily living and social integration.

Although traditional interventions, such as physiotherapy, occupational therapy, and adapted physical education, have proven effective in enhancing motor outcomes, they often face challenges related to scalability, cost, and sustained learner engagement (Novak et al., 2020). These limitations are particularly evident in inclusive educational settings, where maintaining individualized interventions within classroom environments is challenging. Consequently, there is an increasing demand for complementary approaches that are pedagogically meaningful and scalable within formal education systems. One such approach is the integration of immersive technologies, particularly virtual reality (VR), into educational practices. VR is broadly defined as an interactive, computer-generated environment that allows users to engage in three-dimensional simulations through multisensory feedback (Radianti et al., 2020). Its educational value lies in its ability to facilitate embodied experiential learning, enabling learners to engage in tasks rather than passively receive information. This approach aligns closely with the principles of motor learning, which emphasize repetition, feedback, and task-specific practice.

The pedagogical affordances of virtual reality (VR) are particularly pertinent in motor skill development. First, VR offers risk-free simulation environments where learners can engage in complex or potentially hazardous tasks without facing real-world repercussions. Second, it facilitates repeated practice under controlled and consistent conditions, thereby aiding the consolidation of motor patterns. Third, VR systems provide immediate multimodal feedback, enabling learners to adjust their performance in real time. Additionally, VR supports embodied cognition by integrating physical movements with cognitive processes, thus enhancing sensorimotor learning. However, it is

crucial to recognize that VR's effectiveness is not intrinsic to the technology itself; rather, it depends on the design of the learning environment and its alignment with pedagogical objectives. Indeed, evidence indicates that increased immersion does not necessarily correlate with improved learning outcomes and may even impose an additional cognitive load if not appropriately structured (Makransky & Lilleholt, 2018).

In special education, VR has been applied across various domains, including social skills training, cognitive development, and physical rehabilitation. A substantial body of research has concentrated on children with autism spectrum disorder (ASD), demonstrating that virtual environments can offer structured and predictable contexts for practicing social interactions (Mesa-Gresa et al., 2018). In rehabilitation settings, VR-based motor training has shown promising results in enhancing balance, coordination, and upper-limb function, particularly among children with cerebral palsy (Chen et al., 2018; Xue et al., 2025). Despite these advancements, the literature is still fragmented. Many studies are characterized by small sample sizes, limited methodological rigor, and short intervention durations, which constrain the generalizability of the findings (Zhang et al., 2023). Furthermore, a significant portion of research has been conducted in clinical rather than educational contexts, raising questions about the ecological validity and transferability of results to classroom settings (Parsons & Cobb, 2011).

Importantly, while VR has been extensively utilized to target social and cognitive outcomes, motor skill development has not yet been sufficiently established as a central focus within educational VR research for special educational needs (SEN) populations. This represents a notable gap, given the foundational role of motor skills in learning and participation in sports. Additionally, existing studies tend to adopt single-perspective approaches, focusing either on student outcomes or teacher perceptions without integrating these dimensions into a unified framework. This fragmentation limits our understanding of how teacher preparation, implementation quality, and student experience

interact to shape the effectiveness of VR-based interventions.

Teacher readiness is pivotal in bridging this gap. The incorporation of virtual reality (VR) into educational practices demands more than mere technical proficiency; it requires the capability to design, implement, and adapt immersive learning experiences in accordance with pedagogical objectives. The Technological Pedagogical Content Knowledge (TPACK) framework underscores the need to integrate technological, pedagogical, and content knowledge to facilitate meaningful technology use in education (Mishra & Koehler, 2006). Nonetheless, empirical evidence suggests that educators encounter numerous obstacles to VR adoption, including inadequate training, insufficient technical support, time constraints, and uncertainty regarding instructional integration (Carpenter et al., 2023; Stålhandske et al., 2024). These challenges are particularly acute in special education settings, where accessibility, differentiation, and classroom management are paramount. Consequently, VR integration should be conceptualized as a systemic and pedagogical process, rather than merely a technological innovation.

Collectively, the literature identifies several critical gaps. First, there is a dearth of integrative studies that examine teacher training, classroom implementation, and student experiences within a unified analytical framework. Second, cross-national research on VR-based interventions in special education is limited, despite the impact of contextual factors on technology adoption and effectiveness. Third, motor skill development is underrepresented as a primary outcome in VR-based educational research for special educational needs (SEN) populations. Finally, the relationship between teacher preparedness and student-perceived outcomes remains insufficiently explored. To address these gaps, the present study conducts a multi-country, multi-perspective evaluation of a VR-based motor skills training program implemented within an Erasmus+ project across Türkiye, Greece, Spain, and Poland. This study integrates three complementary levels of analysis: (a) teacher evaluation of VR training workshops, (b) teacher evaluation of the VR-based intervention

following classroom implementation, and (c) student feedback on the intervention. By triangulating these perspectives, this study transcends fragmented research designs to provide a comprehensive understanding of how VR-based motor skills training operates within authentic educational contexts. Furthermore, the cross-national design facilitates the examination of contextual variation, contributing to the development of more scalable and context-sensitive models of VR integration in special education settings.

Research Questions

RQ1. How do teachers evaluate VR training workshops in terms of content relevance, instructional quality, and technical/organizational adequacy?

RQ2. How do teachers evaluate the VR-based motor skills program following classroom implementation, specifically in terms of (a) program content and structure, (b) pedagogical effectiveness, (c) technological usability, and (d) observed student outcomes?

RQ3. How do students perceive the VR-based motor skills intervention in terms of (a) enjoyment, (b) perceived learning, (c) self-confidence, and (d) engagement?

2. Methodology

Research Design

This study employed a quantitative, cross-sectional, multi-site survey to assess a virtual reality (VR)-based motor skills training program for children with special educational needs (SEN) across four European nations. This research employed descriptive, correlational, and comparative analytical approaches to capture diverse evaluative perspectives. Three distinct instruments were administered to evaluate (a) teacher perceptions of a specialized VR training workshop, (b) teacher assessments of the VR-based motor skills program following classroom implementation, and (c) student feedback on the VR intervention.

Participants

Three distinct samples were recruited through purposive sampling for an Erasmus+ collaborative

project. The first sample comprised 130 teachers and educational professionals who participated in a virtual reality (VR) training workshop. The participants were distributed across four countries: Türkiye (n = 34), Greece (n = 35), Spain (n = 30), and Poland (n = 31). The majority of participants were female (76.2%, n = 99), with males accounting for 23.8% (n = 31). Participants represented diverse professional roles, with special education teachers forming the largest group (60.0%), followed by occupational therapists (5.4%), pre-primary teachers (5.4%), and physical therapists (3.8%). Teaching experience varied widely, with 11.5% reporting 0–5 years, 23.1% reporting 6–10 years, 16.2% reporting 11–15 years, 12.3% reporting 16–20 years, 18.5% reporting 21–25 years, and 18.5% reporting over 25 years. Regarding institutional affiliation, 57.7% were employed in public schools and 32.3% in special-education centers. Notably, 69.2% of the participants reported no prior experience with VR or digital tools in their teaching practice.

The second sample consisted of 52 teachers who evaluated the VR-based motor skills training program after its classroom implementation. The participants were from three countries: Greece (n = 40), Poland (n = 6), and Spain (n = 6). The sample included 31 women (59.6%) and 21 men (40.4%). Special education teachers comprised the majority (57.7%), followed by occupational therapists (17.3%) and physiotherapists (15.4%). The distribution of teaching experience was relatively balanced: 0–5 years (9.6%), 6–10 years (25.0%), 11–15 years (21.2%), 16–20 years (23.1%), 21–25 years (13.5%), and over 25 years (7.7%).

The third sample included 166 students with special educational needs who participated in VR-based motor skills activities. These students were located in Greece (n = 100), Spain (n = 36), and Poland (n = 30). Given the participants' vulnerability, demographic data collection was intentionally limited to the country of enrollment, in accordance with ethical guidelines for research involving children with special educational needs.

Context and Procedure

This study was conducted as part of an Erasmus+ collaborative project involving partner institutions. Training sessions were held in laboratory settings equipped with computers and VR headsets, including the Meta Quest 2 and Meta Quest 3. The training program introduced teachers to fundamental VR concepts, development environments, and content-creation methods. Participants engaged in hands-on VR experiences, explored immersive environments, and interacted with a VR application specifically designed to support motor skill development in children with special educational needs (SEN). Following the workshop, the participating teachers implemented the VR-based program in their classrooms with students with SEN. Teacher evaluation forms were administered after classroom implementation, and student feedback was collected after the VR intervention sessions. Ethical approval was obtained from all partner institutions, and informed consent was secured from all participants (and from parents or guardians for student participants) before data collection.

Instruments

Workshop Evaluation Scale (WES). The WES was specifically developed for this project to evaluate teachers' perceptions of the VR training workshops. This instrument comprises 12 items, each measured on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The items were conceptually organized into three domains: Content Relevance (three items; e.g., "The workshop content was relevant to my professional needs"), Instructional Quality (4 items; e.g., "The methods and activities used were effective"), and Technical and Organizational Adequacy (5 items; e.g., "Technical support was sufficient"). The internal consistency was excellent for the overall scale ($\alpha = .97$) and for each subscale: Content Relevance ($\alpha = .91$), Instructional Quality ($\alpha = .94$), and Technical and Organizational Adequacy ($\alpha = .95$). Additionally, two open-ended items were included to gather qualitative feedback on the most beneficial aspects and areas of improvement.

Teacher Evaluation Form (TEF). The TEF was designed to capture teachers' assessments of the

VR-based motor skills program following its classroom implementation. This instrument included 18 items on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), organized into four theoretically informed subscales: Program Content and Structure (PCS; 5 items; e.g., "The program objectives are clearly defined"), Pedagogical Effectiveness (PE; 5 items; e.g., "The program supports the development of fine and gross motor skills"), Technological Usability (TU; 5 items; e.g., "VR technology is easy to use in the classroom"), and Observed Student Outcomes (OSO; 3 items; e.g., "Students show improvement in motor coordination and balance"). The internal consistency was excellent for the total scale ($\alpha = .97$) and all subscales: PCS ($\alpha = .92$), PE ($\alpha = .93$), TU ($\alpha = .93$), and OSO ($\alpha = .92$).

Student Feedback Form (SFF). The SFF was developed using child-friendly language to collect self-reported perceptions from students with SEN. It consists of 10 items on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), conceptually mapped onto four dimensions: Enjoyment (three items; e.g., "I really liked the virtual reality activities"), Perceived Learning (2 items; e.g., "I learned new things during the VR sessions"), Self-Confidence (2 items; e.g., "I feel more confident when I do physical activities"), and Engagement (3 items; e.g., "The activities were easy to understand"). The internal consistency was excellent for the total scale ($\alpha = .96$) and for the subscales: Enjoyment ($\alpha = .94$), Perceived Learning ($\alpha = .94$), Self-Confidence ($\alpha = .82$), and Engagement ($\alpha = .89$). Three open-ended questions were included to collect qualitative responses from the students.

Data Analysis

Data were analyzed using both descriptive and inferential statistical methods. Descriptive statistics, including means, standard deviations, and ranges, were calculated for all the scale items and composite subscale scores. Internal consistency was assessed using Cronbach's alpha, with values above .70 deemed acceptable, above .80 considered good, and above .90 regarded as excellent (George & Mallery, 2020). Pearson product-moment correlations were computed to investigate the relationships among

the subscales within and across the instruments. The normality of the distributions was evaluated using the Shapiro–Wilk test, supplemented by skewness and kurtosis indices. Given that the Shapiro–Wilk tests indicated significant deviations from normality across all composite scores ($p < .001$) and several distributions exhibited pronounced negative skewness (ranging from -1.78 to -0.65), non-parametric alternatives were employed for the group comparisons.

3. Results

Teacher Evaluations of the VR Training Workshop

The initial research question investigated how educators assessed the virtual reality (VR) training workshop across three specific dimensions: content relevance, instruction quality, and adequacy of technical and organizational aspects. The descriptive statistics for all 12 items, along with the composite subscale scores, are presented in Table 1.

As illustrated in the table, the educators provided highly favorable assessments across all workshop dimensions. The overall mean evaluation score was $M = 4.43$ ($SD = 0.73$), reflecting strong concurrence with the quality and utility of the training experience. Among the three subscales, Technical and Organizational Adequacy received the highest ratings ($M = 4.48$, $SD = 0.76$), followed by Instructional Quality ($M = 4.43$, $SD = 0.82$), and Content Relevance ($M = 4.32$, $SD = 0.89$). At the item level, the workshop environment (Item 8; $M = 4.52$) and technical support (Item 10; $M = 4.51$) garnered the highest endorsements, whereas workshop content relevance (Item 1; $M = 4.27$) and program applicability (Item 3; $M = 4.31$) received comparatively lower—albeit still strongly positive—ratings, indicating a modest opportunity for enhancing the contextual alignment of training content with teachers' specific professional circumstances.

Table 1

Descriptive statistics for workshop evaluation scale items and subscales

Item / Subscale	<i>n</i>	<i>M</i>	<i>SD</i>
<i>Content Relevance (CR)</i>		4.32	0.89
1. Workshop content relevance	130	4.27	0.97
2. Motor skills content	128	4.38	0.93
3. Applicability to real situations	130	4.31	0.88
<i>Instructional Quality (IQ)</i>		4.43	0.82
4. Methods and activities	130	4.38	0.86
5. Training materials	129	4.47	0.81
6. Trainer delivery	130	4.48	0.76
7. New ideas for motor skills	130	4.41	0.85
<i>Technical & Organizational (TO)</i>		4.48	0.76
8. Workshop environment	130	4.52	0.77
9. Duration and time management	130	4.48	0.81
10. Technical support	130	4.51	0.79
11. Overall expectations met	130	4.46	0.84
12. VR applications are easy to apply	130	4.45	0.77
<i>Overall Evaluation</i>	130	4.43	0.73

Note. M = mean; SD = standard deviation. The subscale scores are item-level averages. All items were measured on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).

Teacher Evaluations of the VR-Based Motor Skills Program

The second research question examined teachers' evaluations of the implemented VR-based program

across four dimensions. The descriptive statistics are shown in Table 2. Teachers consistently provided positive evaluations of the VR-based program across all the study dimensions. The overall Teacher Evaluation Form (TEF) mean was

$M = 4.33$ ($SD = 0.57$). The highest subscale mean was observed in Pedagogical Effectiveness ($M = 4.44$, $SD = 0.60$), primarily due to high ratings for promoting student engagement (Item 7; $M = 4.67$) and supporting motor skills development (Item 6; $M = 4.62$). Technological usability received the lowest rating among the four dimensions ($M = 4.26$, $SD = 0.63$), with ease of classroom use receiving a relatively modest endorsement (Item 11; $M = 3.98$), indicating that practical implementation challenges remain a concern. Notably, the technology's ability

to enhance student motivation (Item 15; $M = 4.65$) was rated as the highest individual item across the entire TEF, suggesting that teachers perceive VR's motivational affordance as the program's most significant strength. Within Observed Student Outcomes, teachers reported moderate to strong agreement that students exhibited improvements in motor coordination ($M = 4.42$) and confidence ($M = 4.35$), with somewhat lower agreement regarding anxiety reduction ($M = 4.17$).

Table 2

Descriptive statistics for teacher evaluation form subscales and items

Item / Subscale	<i>n</i>	<i>M</i>	<i>SD</i>
<i>Program Content & Structure (PCS)</i>	52	4.28	0.60
1. Objectives clearly defined	52	4.50	0.54
2. Content suitable for SEN children	52	4.48	0.70
3. Logical activity sequence	52	4.33	0.68
4. Sufficient duration/frequency	52	3.96	0.86
5. Developmentally appropriate materials	52	4.12	0.88
<i>Pedagogical Effectiveness (PE)</i>	52	4.44	0.60
6. Motor skills development support	52	4.62	0.63
7. Student engagement promotion	52	4.67	0.62
8. Individualized learning	52	4.58	0.64
9. Measurable learning outcomes	52	4.37	0.74
10. Collaboration support	52	3.96	0.82
<i>Technological Usability (TU)</i>	52	4.26	0.63
11. VR ease of classroom use	52	3.98	0.80
12. Clear technical instructions	52	4.13	0.84
13. VR-pedagogy alignment	52	4.42	0.70
14. System reliability	52	4.12	0.78
15. Motivation enhancement	52	4.65	0.52
<i>Observed Student Outcomes (OSO)</i>	52	4.31	0.71
16. Motor coordination improvement	52	4.42	0.67
17. Increased student confidence	52	4.35	0.79
18. Reduced anxiety	52	4.17	0.88
<i>Overall TEF Score</i>	52	4.33	0.57

Note. $N = 52$. All items were measured on a 5-point Likert scale. The subscale scores represent item-level averages.

Student Perceptions of the VR Intervention

The third research question examined student perceptions in four dimensions. The item-level and subscale descriptive statistics are shown in Table 3. Students expressed predominantly positive perceptions of the VR-based motor skills intervention, with an overall mean score of $M = 4.37$ ($SD = 0.81$). The dimension of enjoyment

received the highest ratings ($M = 4.57$, $SD = 0.69$), with students strongly endorsing their interest in future VR activities (Item 9; $M = 4.59$) and their overall enjoyment of VR experiences (Item 1; $M = 4.58$). Engagement was also rated highly ($M = 4.35$, $SD = 0.80$), with students reporting strong feelings of safety while using the VR equipment (Item 3; $M = 4.42$). The self-confidence subscale had the lowest

mean score ($M = 4.21$, $SD = 1.03$), with Item 7 (willingness to try new movements) exhibiting the highest variability ($SD = 1.21$), indicating significant individual differences in students' perceived

confidence. Perceived learning was rated moderately high ($M = 4.26$, $SD = 0.98$), suggesting that students recognized the educational value of the VR experience, alongside its recreational appeal.

Table 3

Descriptive Statistics for Student Feedback Form Items and Subscales

Item / Subscale	<i>n</i>	<i>M</i>	<i>SD</i>
Enjoyment		4.57	0.69
1. Liked VR activities	166	4.58	0.75
9. Want more VR activities	166	4.59	0.71
10. VR made learning fun	165	4.53	0.78
Perceived Learning		4.26	0.98
4. Learned new things	166	4.27	1.03
6. VR helped move better	163	4.25	1.01
Self-Confidence		4.21	1.03
5. More confident in physical activity	166	4.33	0.98
7. Not afraid of new movements	166	4.08	1.21
Engagement		4.35	0.80
2. Activities are easy to understand	166	4.30	0.97
3. Felt safe using VR	165	4.42	0.77
8. Liked activities with classmates	166	4.33	0.97
Overall Student Feedback	166	4.37	0.81

Note. Items with $n < 166$ reflect minor missing data. All items were measured on a 5-point Likert scale.

Table 4 displays the correlation matrices for TEF and SFF. In the TEF (Panel A), all four subscales exhibited strong and statistically significant intercorrelations, with Pearson coefficients ranging from $r = .72$ to $r = .85$ (all $p < .001$). The strongest association was between Program Content and Structure and Technological Usability ($r = .85$), suggesting that teachers who perceived the program

as well-structured also rated the technology as more usable. In the SFF (Panel B), subscale intercorrelations were similarly strong, ranging from $r = .76$ to $r = .89$, with the strongest association between Perceived Learning and Self-Confidence ($r = .89$), indicating that students who felt they learned more also reported greater gains in confidence.

Table 4

Pearson correlation matrices for instrument subscales

Panel A: Teacher evaluation form subscales

	<i>PCS</i>	<i>PE</i>	<i>TU</i>	<i>OSO</i>
PCS	—			
PE	.80***	—		
TU	.85***	.78***	—	
OSO	.72***	.83***	.81***	—

Panel B: Student feedback form subscales

	<i>Enjoyment</i>	<i>Learning</i>	<i>Confidence</i>	<i>Engagement</i>
Enjoyment	—			
Learning	.80***	—		
Confidence	.76***	.89***	—	
Engagement	.78***	.83***	.84***	—

Note. *** $p < .001$. PCS = Program Content and Structure; PE = Pedagogical Effectiveness; TU = Technological Usability; OSO = Observed Student Outcomes.

4. Discussion

This study presents a comprehensive evaluation of a virtual reality (VR)-based motor skills training program for children with special educational needs (SEN) from multiple countries and perspectives. It integrates assessments from teacher workshops, program evaluations, and student feedback. The findings contribute to the emerging body of evidence on VR applications in special education by addressing several methodological gaps identified in the literature, such as the lack of integrated stakeholder perspectives, limited cross-national comparisons, and insufficient focus on motor skill training in educational VR research.

Teacher Evaluation of the VR Workshop (RQ1)

Teachers' overwhelmingly positive evaluations of the VR training workshop (overall $M = 4.43$) indicate that the professional development program effectively met participants' needs for accessible and practice-oriented VR training. The finding that Technical and Organizational Adequacy was the highest-rated dimension aligns with prior research emphasizing the importance of infrastructure quality and logistical support in shaping teachers' technology-training experiences (Carpenter et al., 2023). Notably, the workshop was equally valued by teachers with and without prior VR experience, suggesting that the training design effectively accommodated diverse baseline skill levels—a feature identified by Mishra and Koehler (2006) as essential within the TPACK framework for building technological, pedagogical, and content knowledge.

The slightly lower ratings for Content Relevance, while still strongly positive, suggest that future iterations could benefit from greater contextualization of training content to the specific curricular frameworks and student populations that

teachers encounter. This finding resonates with Ståhlhandske et al.'s (2024) observation that special education teachers value VR training that directly addresses the practical challenges of their specific instructional contexts rather than offering generic technological demonstrations.

Teacher Evaluations of the VR Program (RQ2)

Teachers' evaluations of the implemented program confirmed the pedagogical promise of VR for motor skill development in SEN populations. The high ratings for Pedagogical Effectiveness ($M = 4.44$), particularly the strong endorsement of VR's capacity to promote student engagement ($M = 4.67$) and support motor skill development ($M = 4.62$), corroborate the theoretical propositions of embodied cognition in immersive learning environments (Johnson-Glenberg, 2018). These results extend the findings from clinical rehabilitation contexts (Xue et al., 2025; Chen et al., 2018) to educational settings, demonstrating that teachers perceive VR-based motor interventions as pedagogically effective when implemented within inclusive school environments.

The finding that Technological Usability received the lowest subscale mean, with ease of classroom use rated at $M = 3.98$, highlights a persistent implementation challenge. This result is consistent with the broader VR adoption literature, which consistently identifies technical barriers—including device management, troubleshooting demands, and integration with existing classroom routines—as significant obstacles to sustainable VR implementation (Fernández-Cerero et al., 2024; Carpenter et al., 2023). The juxtaposition of high pedagogical value ratings with moderate usability scores suggests that, while teachers are convinced of VR's educational merit, the practical demands of technology management in classroom settings

require continued attention through improved hardware design, enhanced technical support infrastructure, and ongoing professional development.

Students' highly favorable perceptions of the VR intervention, with enjoyment receiving the highest rating ($M = 4.57$) and a strong expressed desire for continued VR activities ($M = 4.59$), affirm VR's motivational affordances for learners with SEN. These findings align with Makransky and Lilleholt's (2018) structural model of emotional engagement in immersive learning environments and extend prior work on VR motivation in general education populations to children with diverse, special needs. The comparatively lower ratings for self-confidence, coupled with high variability in the item assessing willingness to try new movements ($SD = 1.21$), suggest that while VR effectively engages students, its capacity to build motor confidence may be more variable and potentially dependent on individual learner characteristics, disability type, and intervention duration. This finding echoes Zhang et al.'s (2023) systematic review, which noted inconsistent outcomes in confidence during VR motor interventions for individuals with developmental disabilities. Confidence building through VR may require more extended or individually tailored intervention protocols. The strong correlation between Perceived Learning and Self-Confidence ($r = .89$) further implies that interventions designed to make learning gains more salient to students may simultaneously enhance confidence outcomes.

Theoretical and Practical Contributions

This study makes several theoretical contributions. First, by integrating teacher and student perspectives within a unified evaluative framework, it demonstrates the analytical value of multi-stakeholder design for educational technology evaluation. This approach has been advocated but rarely implemented in VR research (Radianti et al., 2020). Second, the cross-national design provides empirical evidence for the contextual moderation of VR implementation outcomes, extending the TPACK framework (Mishra & Koehler, 2006) by demonstrating that broader institutional and cultural factors shape the interaction between

technological, pedagogical, and content knowledge (TPACK). Third, this study contributes to the underdeveloped literature on VR-based motor skills training in educational settings for children with SEN (Zhang et al., 2023), providing evidence that VR can be perceived as both pedagogically effective and motivationally engaging in this domain.

Practical implications include the need for professional development programs that combine technical VR training with contextualized pedagogical guidance tailored to the specific needs of the SEN population. The persistent gap between pedagogical value ratings and usability scores suggests that VR developers and educational technology providers should prioritize classroom-friendly design features, including simplified interfaces, robust hardware, and clear implementation protocols. The observed cross-national variation suggests that VR program dissemination should incorporate local adaptation processes that address country-specific educational contexts, teacher training cultures, and infrastructure conditions.

Limitations

This study has several limitations. First, the cross-sectional design precludes causal inferences regarding the effects of VR training on teacher competence and student motor outcomes. Second, unequal sample sizes across countries limit the statistical power of cross-national comparisons and may have contributed to the non-significant results for several TEF subscales. Third, student feedback was collected via self-report instruments with child-friendly but simplified language, which may have introduced response bias, particularly among younger children with cognitive or communication difficulties. Fourth, the instruments were developed specifically for this project and, while demonstrating excellent reliability, have not yet been subjected to confirmatory factor analysis or to criterion validation. Finally, the study relied on perceptual measures rather than objective motor skill assessments, limiting the conclusions about the program's actual developmental impact.

5. Conclusion

This study provides evidence that VR-based motor skills training for children with SEN is perceived positively by both implementing teachers and participating students across multiple European countries. Teachers evaluated the professional development workshop and the implemented program favorably, particularly endorsing VR's capacity to promote student engagement and support motor skills development. Students reported high levels of enjoyment, learning, and engagement, as well as a strong desire for continued VR experiences. However, the study also revealed important nuances: usability challenges persist in classroom implementation, confidence-building effects vary across students, and substantial cross-national differences indicate that contextual factors significantly shape VR program outcomes. The divergence between teacher and student evaluations in certain countries further underscores the need for a multi-perspective program evaluation.

Future research should employ longitudinal designs and objective motor skill outcome measures to assess the developmental impact of VR interventions. Randomized controlled trials comparing VR-augmented programs with conventional approaches would strengthen the causal evidence base. Confirmatory factor analysis of the instruments developed for this study would enhance their psychometric credentials for use in future investigations. Additionally, mixed-methods designs incorporating qualitative data from classroom observations and in-depth interviews would enrich our understanding of the mechanisms through which VR supports motor skill development in children with SEN. Cross-national studies with larger, more balanced samples should investigate the specific cultural, institutional, and pedagogical factors that moderate VR implementation outcomes, ultimately contributing to the development of adaptable, evidence-based models of VR integration for inclusive education.

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