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Technology-Supported Physical Education as a Pathway to Motor Competence, Movement Motivation, and Functional Health Promotion

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Abstract: Physical education plays a foundational role in developing motor competence, movement literacy, and health-related behaviours among young populations outcomes that carry long-term functional and rehabilitative significance. Despite the recognized potential of technology-enhanced learning, its application specifically to motor skill acquisition and movement competence development in school-based physical education remains under-explored. This study examined the effects of integrating Virtual Reality (VR) and Aug-mented Reality (AR) technologies into physical education on students' learning motiva-tion and movement concept understanding, constructs that serve as key mediators of long-term physical function, movement adherence, and health-related behaviour. A quasi-experimental pretest–posttest control group design was employed with 40 junior high school students in West Bandung Regency, Indonesia, divided equally into experimental (VR/AR-integrated learning) and control (conventional instruction) groups. Data were col-lected using validated motivation scales and cognitive understanding assessments, and analysed using the independent samples t-test following confirmation of normality and homogeneity assumptions. Results demonstrated significantly greater improvements in both motivation and movement concept understanding in the experimental group com-pared to controls. These findings suggest that immersive technology-based learning not only enhances educational engagement but also strengthens the foundational competen-cies required for sustained physical activity, disability prevention, and technology-supported health promotion outcomes highly relevant to rehabilitation science and func-tional health contexts.

Keywords: Physical Education; Virtual Reality; Augmented Reality; Motor Learning; Movement Competence; Motivation; Functional Health; Rehabilitation Technology; Tech-nology-Assisted Health Promotion

1. Introduction

Physical education is an integral component of the education system, aimed at developing physical, cognitive, and affective capacities through structured and planned movement activities. Beyond its educational role, physical education consti-tutes a foundational context for developing motor competence and health-related physical fitness attributes with direct implications for functional performance and re-habilitation across the lifespan [1]. In practice, education physical No only play a role in increase fitness physical, but also in form motor skills, understanding draft move-ment, and attitude positive to activity physique as part from style life Healthy [2], [3].

However, education physical education at school often face challenge in increase motivation participant educate for active participate in activity physical. Many participants students who show low interest to lesson sports, which has an impact on lowering level involvement and participation they in activity physique as well as has implications for low quality results learning and habits life active participant educate [4], [5]. This condition underscores that motivational engagement is a necessary factor to be addressed in efforts to improve the effectiveness of physical education, and that its long-term consequences for physical function and health-related behaviour warrant particular attention in research and practice.

Motivation to engage in physical activity is a determining factor for the level of involvement, effort, and success of students in physical education. Importantly, motivational engagement in physical education has implications that extend well beyond the school setting: students who develop strong intrinsic motivation for movement during adolescence are more likely to maintain physically active lifestyles in adulthood, contributing to the prevention of functional decline, non-communicable disease, and disability [6], [7]. Motivation not only shapes students' willingness to participate in physical activities but also governs the consistency and quality of their engagement throughout the learning process [8]. In the context of education physical, motivation Study can explain through various approach theoretical. self-determination theory emphasizes importance fulfillment need psychological basic, namely autonomy, competence, and connectedness, as driving factors motivation intrinsic participant educate [9], [10]. Furthermore, achievement goal theory explains that orientation objective based mastery (task-oriented) encourages effort, persistence, and involvement learn more tall compared to orientation based performance [11], [12]. Perspective this reinforced by expectancy value theory which states that motivation participant educate influenced by beliefs to success (expectancy) and the value given to activity learning [13]. Accordingly, motivation in physical education shapes the engagement and quality of student participation in the learning process, working in concert with understanding as a complementary indicator of students' learning success both serving as mediators of longer-term physical function and health-related outcomes.

Understanding is one of the fundamental cognitive aspects of the learning process, reflecting students' ability to interpret, organise, and apply information in a meaningful way [14]. Within the framework of learning taxonomy, understanding represents a cognitive level indicating that students are not only capable of remembering information but are also able to explain, connect, and apply concepts learned in various contexts [15]. In the context of education physical, understanding No only covers aspect theoretical, but also involves understanding to skills movement, game strategy, and principle activity healthy physique [16]. In general theoretical, understanding learning can also explained through the cognitive theory of multimedia learning which states that learning will more effective when information served through combination visual and verbal channels so simplify the processing process information in memory Work [17]. In addition, constructivism emphasises that understanding is built actively by students through meaningful and contextual learning experiences, such that students not only receive information passively but construct knowledge through interaction with the learning environment [18], [19]. Therefore, understanding serves as an important indicator for evaluating the success of physical education comprehensively, while the advancement of technology presents opportunities to support improvements in both motivation and understanding through more innovative and adaptive learning approaches, including those with implications for motor learning and functional health.

Progress fast technology and convenience access knowledge good in the field economy and social has become characteristics main in the digital era which is marked with increasing integration technology in various aspect life humans, including education [20]. Progress technology moment This speed up transition to a fully digital and encouraging environment change paradigm in the learning process from conventional going to learning based technology [20]. The digital revolution has bring method life new integrated close with various device electronics that have implications for change pattern interaction, communication, and learning [21]. Development technology information and communication has bring change significant in various aspect life, including in the world of education, in particular education the current physical start adopt various innovation technology in the learning process [22]–[25]. Thus, technology has become an essential element in transforming physical education towards a more modern, adaptive approach one with potential implications not only for educational outcomes but also for functional movement competence and health promotion.

The advancement of technology in the domain of physical education has yielded considerable benefits, including improved access to information, more interactive instructional methods, and greater flexibility in learning delivery that allows the learning process to be conducted more effectively and adaptively according to students' needs [26]. By integrating technology into physical education, student motivation and participation can be enhanced because learning becomes more engaging, contextual, and experientially grounded [26]. Technology also enables the provision of faster and more accurate feedback on student performance, alongside diverse interactive and varied learning materials that support data-driven evaluation and sustainable assessment practices [27]. Therefore that, utilization technology in education physical potential increase quality of process and results learning in a way significant.

Technology integration in physical education refers to teachers' ability to effectively and efficiently utilise various technological tools to improve the learning process and student outcomes [28], [29]. Physical Education Teacher must capable integrate technology in the learning process For increase quality education and shaping character participant healthy and cultured education along with demands competence 21st [26], [30]Technology integration covers use device software, applications, and digital platforms that support activity physical and sports in environment innovative and interactive learning [31]. For example, fitness applications can help students monitor their physical activity such as step counts, caloric expenditure, and activity duration enabling real-time monitoring of physical performance and the provision of constructive, data-informed feedback [27]. Teacher competence in technology integration is therefore a critical factor in the success of digitally-enhanced physical education.

Physical education instruction continues to encounter numerous common challenges in practice, including inadequate facilities and infrastructure, insufficient teacher competency in technology use, and low student motivation all of which collectively impact the quality of the learning process and outcomes. Additionally, limited instructional time and restricted access to continuing professional development programmes impede optimal physical education delivery across educational units. These challenges highlight a persistent gap between the potential of technology utilisation and its actual implementation in the field. In Indonesia specifically, the implementation of technology-based physical education continues to face significant challenges related to infrastructural readiness and teacher competency in optimal technology use. Although technology holds considerable potential for improving learning quality, its implementation remains uneven and requires systematic, contextually appropriate approaches. The implications for functional movement development and health promotion are consequently also unrealised at scale, underscoring the need for evidence-based, technology-supported physical education models.

Technology-based learning innovation constitutes one of the most relevant strategies for addressing the persistent challenges in physical education delivery [32]. Approach This No only improvement oriented involvement participant education, but also on optimizing the learning process through utilization digital technology in systematic and integrated [33]. Digitalisation in physical education carries increasing urgency because it can increase student involvement, facilitate data-driven evaluation, provide varied learning experiences, and promote healthy active lifestyles through technology that meets 21st-century learning needs [34]–[36]. With Thus, innovation-based technology becomes need strategic in development learning education modern physical.

The use of technology in physical education can increase student participation and involvement in sport activities while providing more meaningful learning experiences [37]. In addition, the development innovation technology in learning education physical covers use application fitness and wearable technology [38]–[41], learning based on Virtual and Augmented Reality [42], [43], gamification, online and hybrid learning, and utilization intelligence artificial intelligence (AI) in training sports that show existence transformation significant in approach learning education physical [44]. Technology-based learning innovation has demonstrated the capacity to significantly improve learning quality, student engagement, and academic outcomes across various educational contexts [45]. These findings collectively demonstrate the substantial potential of technology to comprehensively transform physical education towards more effective, health-promoting, and functionally relevant practice.

Most existing studies have examined technology use in physical education in general terms, without specifically investigating the integration of VR and AR for simultaneous improvement of motivation and movement understanding. Crucially, the rehabilitation and functional health implications of such technologies in school-based physical education have received limited scholarly attention, despite the established role of early motor competence in preventing functional decline and supporting healthy ageing [42], [43]. In addition, research investigating the effectiveness of learning based on virtual reality and augmented reality in school-based physical education remains relatively limited, particularly in relation to functional health and motor learning with rehabilitation implications. This gap indicates the need for further exploration of the effectiveness of immersive technologies in supporting physical education. Technology integration in physical education continues to develop in response to the growing need for more interactive, contextual, and experientially grounded learning approaches. The use of immersive technologies such as VR and AR provides opportunities to deliver more realistic learning experiences, enabling students to understand movement concepts and physical activities more deeply an approach that not only increases student involvement in learning but also strengthens cognitive development and movement competence through comprehensive engagement with studied material.

While various studies have examined technology use in physical education, the simultaneous application of immersive VR and AR technologies to motivation and movement concept understanding in school settings remains underexplored, particularly in relation to functional health and rehabilitation implications. Evidence that motivational engagement and movement competence cultivated during adolescence serve as mediators of long-term physical function and disability prevention underscores the importance of identifying effective, scalable technology-based approaches. This study accordingly aimed to investigate the implementation of VR/AR-integrated physical education as a technology-supported movement intervention, examining its effects on student motivation and movement concept understanding, and exploring its relevance to motor learning with rehabilitation implications, prevention of functional decline, and technology-assisted health promotion.

2. Materials and Methods

2.1 Design

This study employed a quasi-experimental method with a pretest–posttest control group design [46]. This method was used to test the effect of technology-based physical education innovation integrating VR and AR on improvements in movement concept understanding and motivation. The research design involved two learning groups: an experimental group that received physical education integrated with VR and AR technology, and a control group that received conventional physical education without technology integration. Prior to the intervention, both groups received a pretest (O1) to measure baseline movement concept understanding and motivation. Subsequently, the experimental group received technology-based learning (X) while the control group received conventional learning (C). Following the completion of the learning period, both groups completed a posttest (O2) to measure changes in understanding and motivation after the intervention. The research design is depicted as follows:

Table 1. Pretest– Posttest Control Group Design

Group	Pre Test	Treatment	Posttest
R 1	O 1	X	O2
R 2	O 1	C	O2

Information:
R1 : Group experiment (integration of virtual reality and augmented reality)
R2 : Group control (without integration technology)
O1 : Pretest
X : Treatment learning based on virtual reality and augmented reality
C : Learning conventional
O2 : Posttest

This design was used to compare learning outcome changes between the experimental and control groups, thereby enabling determination of the effectiveness of VR and AR technology integration in improving movement concept understanding and motivation in physical education.

2.2 Participants

Participants in study This is participant educate level School Intermediate First (Junior High School) in West Bandung Regency. Population study covers all over participant junior high school students who participated learning education physical in the area. Considering its area coverage population, carried out restrictions on population accessible population based on criteria certain, namely: (1) schools own supporting facilities and infrastructure learning based technology, (2) education teacher physical willing and have ability in implement learning-based technology, (3) participants educate in a way active follow learning education physicality, as well as (4) suitability timetable learning with implementation research. Based on criteria mentioned, some school chosen as location research. Cluster random sampling technique was used with sampling units in the form of classes that have been formed in a way natural. This technique refers to two procedures main in taking samples, namely random selection and random assignment [47]. At the random selection stage, the classes available at the school selected scrambled for determine class that is used sample study.

Two classes that have characteristics relatively homogeneous in matter age, level education and abilities beginning participant educate chosen as sample. Random assignment, namely determination class to in group experiments and groups control in a way random. Procedure This aim for minimize potential bias as well as ensure equality characteristics beginning between group. Number sample end in study This is 40 participants educate, which is divided to in two groups, namely 20 participants educate in groups experiment and 20 participants educate in groups control. Determination amount sample based on the number participant educate in selected class in a way experience without existence manipulation, so that reflect condition real in the field.

With Thus, the procedure election sample done in a way systematic, objective, and appropriate with principal representativeness, so that results study expected own validity adequate external in context learning education physical.

2.3 *Procedure*

Procedure study implemented through a number of systematic stages for test influence innovation learning education physical based technology to understanding concept and motivation learning. Stages study started with stage preparation, namely compilation device learning, determination instrument research, as well as coordination with party school related implementation activity research. Stage next is carrying out the pretest, which is aimed for now condition beginning understanding concept and motivation Study before given treatment learning. A pretest was given to second group study with use instruments that have been arranged previous. Next done giving treatment during a number of meeting learning education physical.

In the group experiment implemented learning-based technology with integrating virtual reality and augmented reality as learning media for help visualization technique movement and improve involvement in activity learning. Meanwhile that, group control follows learning education physical with method conventional without integration technology said. After all, over series learning finished implemented, done posttest for measure change understanding concept and motivation Study after treatment given. Pretest and posttest results Then analyzed for now difference improvement results learning between group experiments and groups control. Through stages procedure said, research This expected can give description about effectiveness integration technology in increase quality learning education physical.

3. Results

Analysis descriptive done for give description general about characteristics of the resulting data measurement on variables research. Statistics descriptive used for identify data trends through mark mean and deviation standard (standard deviation), so can describe condition empirical from each group treatment.

Table 2. Statistics Descriptive Variables Motivation and Understanding

Variables	Group	Measurement Time	N	Mean	Std. Error	Standard Deviation	Variance
Motivation	Experiment	Pre-test	20	51.40	1.39	6.23	38.78
		Post-test	20	63.10	1.81	8.12	65.88
		Gain Score	20	11.70	0.62	2.75	7.59
	Control	Pre-test	20	49.40	1.39	6.23	38.78
		Post-test	20	55.50	1.78	7.97	63.53
		Gain Score	20	6.10	0.62	2.77	7.67
Understanding	Experiment	Pre-test	20	61.40	1.39	6.23	38.78
		Post-test	20	73.10	1.81	8.12	65.88
		Gain Score	20	11.70	0.62	2.75	7.59
	Control	Pre-test	20	59.40	1.39	6.23	38.78
		Post-test	20	64.00	1.56	6.96	48.42
		Gain Score	20	4.60	0.30	1.35	1.83

Based on Table 2, it can be seen that that initial average value (pre-test) on both group, good experiment and control, shows relative conditions proportional to the variable motivation and understanding. This indicates that ability beginning participant educate is at a relative level homogeneous before given treatment. After intervention, group experiment shows further improvement tall compared to group control on both variables. On the variable motivation, average grades increased from 51.40 to 63.10 with a gain score of 11.70, while in the group control improvement only achieved a gain of 6.10. The same pattern is also seen in the variable understanding, where the group experiment experience improvement from 61.40 to 73.10 with a gain score of 11.70, while group control only achieved a gain of 4.60. The deviation value standard on gain score shows that improvement in the group experiment tend more consistent compared to group control. This indicates that learning innovative No only increase the average yield learn, but also give greater impact evenly distributed among participant educate. This result show that implementation learning innovative based technology own greater effectiveness tall in increase motivation and understanding Study participant educate compared to with learning conventional.

Assumption test in study This includes normality test and homogeneity test as prerequisite analysis statistics parametric. Normality test done for know whether the data is normally distributed, while the homogeneity test used for test similarities variance between group research. Testing normality using the Shapiro–Wilk test with assistance of SPSS version 20, while the homogeneity test using Levene's Test based on average value (based on mean). Criteria taking decision based on values significance (Sig.), namely the data is stated to be normal and homogeneous if Sig. value > 0.05.

Table 3. Normality Test Results

Variables	Group	Shapiro–Wilk (Sig.)
Motivation	Experiment	0.319
Motivation	Control	0.119
Understanding	Experiment	0.319
Understanding	Control	0.119

Note: *Lilliefors Significance Correction is used*

Based on Table 3, some big mark significance in the Shapiro–Wilk test shows value above 0.05. With consider size relative sample small (n < 50), the Shapiro–Wilk test is used as base taking decision, so that can conclude that the data on both variables normally distributed.

Table 4. Results of Homogeneity Test

Variables	Levene Statistics	df1	df2	Sig.
Motivation	0.073	1	38	0.788
Understanding	5,008	1	38	0.131

Based on Table 4, the value significance of the variable's motivation (0.788) and understanding (0.131) are above 0.05, so can concluded that variance between group nature homogeneous. With Thus, all necessary assumptions in analysis statistics parametric has fulfilled. Next, the analysis to be continued using independent samples t-test for identify difference between group experiments and groups control on variables motivation and understanding learning. Analysis done for test difference between group experiments and groups control on variables motivation and understanding learning. Testing using independent samples t-test with SPSS version 20 assistance. Levene's test was used for determine similarities variance as base in election approach analysis. Criteria taking decision based on values significance (Sig.), where p < 0.05 indicates existence significant difference between group.

Table 5. Results of the Independent Samples t-Test on the Variables Motivation and Understanding

Variables	Group	Levene's Test (Sig.)	t	df	Sig. (2-tailed)	Mean Difference

Motivation	Experiment with Control	0.79	6.41	38.00	0,000	5.60
Understand-ing	Experiment with Control	0.03	10.34	27.67	0,000	7.10

Based on Table 5, the value Levene's significance on the variable’s motivation of 0.79 (> 0.05) indicates that variance between group experiments and controls nature homogeneous, so that analysis use equal variances assumed approach. On the other hand, on the variable understanding obtained mark significance of 0.03 (< 0.05), which indicates that variance No homogeneous, so that analysis use the equal variances approach is not assumed. The results of the independent samples t-test show that second variables own mark significance of 0.000 ($p < 0.05$), which indicates existence significant difference between group experiments and groups control. On the variable motivation, the average difference of 5.60 shows that group experiment own level more motivation tall compared to group control. While that, on the variable understanding, the average difference of 7.10 shows that group experiment own level greater understanding tall in a way significant compared to group control. In overall, results This show that learning innovative based technology give significant difference in increase motivation and understanding Study participant educate compared to with learning conventional.

4. Discussion

The results demonstrate that VR/AR-integrated physical education produced significantly greater improvements in both motivation and movement concept understanding compared to conventional instruction, highlighting the value of immersive technologies as tools for enhancing functional movement learning. The experimental group showed markedly higher motivation levels, a finding explicable through the lens of self-determination theory, which holds that intrinsic motivation is fostered when learners’ basic psychological needs for autonomy, competence, and relatedness are satisfied. In the context of physical education and motor learning, these motivational gains carry particular relevance: sustained motivation for physical activity is a critical mediator of long-term movement adherence, physical function maintenance, and health-related behaviour constructs central to rehabilitation science and functional health promotion. Technology-enhanced learning environments that fulfil these psychological needs may, therefore, support not only academic engagement but also health-promoting behaviours across the lifespan. The enhanced autonomy, competence, and relatedness afforded by VR/AR learning closely parallel therapeutic principles in motivation-centred rehabilitation, where patient engagement is recognised as essential to functional recovery outcomes [48], [49]. Learning based technology give room for participant educate for more active get involved, explore material in a way independent, and get bait fast and accurate returns, so capable strengthen motivation Study in a way significant.

Use technology in learning education physical allows creation environment learn more dynamic and contextual [50]. Technology such as interactive media and digital platforms are capable of increase attention and interest participant educate, so that they more pushed For participate in activity learning [51]–[53]. Condition This in line with findings that state that integration technology in education physical can increase involvement and participation participant educate [54]. Regarding movement concept understanding, the experimental group demonstrated substantially superior gains compared to controls. This can be explained through cognitive learning theory, which underscores the importance of visual and experiential media in deepening comprehension of movement principles. Crucially, understanding of movement concepts constitutes a foundational prerequisite for functional motor competence: students who genuinely comprehend the biomechanical and strategic principles underlying physical activities are better equipped to translate this knowledge into skilled, efficient, and safe movement patterns a process directly analogous to motor re-learning in rehabilitation populations. Enhanced movement understanding also supports the development of body awareness and self-monitoring capacities relevant to injury prevention and disability avoidance [55]. According to the cognitive theory of multimedia learning, the presentation of information through visual and verbal combination allows participant educate For processing information in a way more effective, so that increase understanding in a way deep [56].

The use of immersive technologies specifically VR and AR in physical education yielded significant contributions to movement understanding, consistent with their established role in motor learning across both educational and rehabilitative contexts. These technologies enable learners to observe and practise movement in richly detailed, contextually realistic environments, supporting concrete understanding of technique and biomechanical principles. This capacity is directly transferable to rehabilitation applications: VR and AR are increasingly employed in physiotherapy and physical rehabilitation to facilitate motor skill recovery, functional movement training, and patient engagement in therapeutic exercise. The present findings therefore provide educational evidence supporting the broader rehabilitative potential of immersive technologies [57], [58]. Learning process No only nature theoretical, but also provides experience practical that strengthens construction knowledge participant educate [59]. Technology-based learning further supports experiential learning principles, wherein students acquire knowledge through direct engagement with movement-relevant activities that mirror real-life physical contexts. This experiential dimension is particularly significant from a functional health perspective, as it cultivates movement competence the ability to perform a range of physical activities effectively and safely which is recognised as a protective factor against functional decline, sedentary lifestyle, and associated non-communicable diseases. Movement competence developed during adolescence is associated with higher physical activity levels in adulthood, reduced disability risk, and better self-reported health outcomes [60]. Approach This allows participant educate for linking concepts learned with practice in a way directly, so that increase understanding and retention information in term long. This is show that technology No only functioning as tool help, but also as a capable learning medium enrich experience Study participant educate.

Findings supported by various study previous which shows that integration technology in learning education physical give impact positive to aspect cognitive and motivational participant educate [61]–[64]. Use application fitness, gamification, as well as interactive digital media proven capable increase motivation, engagement, and outcomes Study participant educate [65]–[67]. This matter show that technology own role strategic in transform learning education physical become more effective and relevant with need participant education in the digital era. In conceptual, learning innovative based technology capable bridge gap between theory and practice in education physical [68]. Participant educate No only accept information in a way passive, but also involved in a way active in the process of exploration, observation, and reflection to material studied [69]–[71]. With Thus, learning becomes more meaningful, adaptive, and development - oriented competence in a way holistic, good from aspect cognitive and affective.

Technology integration creates opportunities for teachers to provide more precise, individualised feedback to students, thereby increasing instructional effectiveness. This personalisation of the learning process has direct analogues in rehabilitation practice, where tailored, data-informed feedback is foundational to effective motor rehabilitation. Digital platforms capable of generating real-time performance data and adaptive feedback loops align closely with the evidence-based principles underpinning technology-assisted health interventions and functional assessment frameworks [72], [73]. Thus, technology serves as a catalyst for improving the quality of physical education in a systematic and sustainable manner, with implications for functional movement development and technology-assisted health promotion that extend well beyond the classroom.

a. Implications for Clinical Rehabilitation and Motor Recovery

The present findings carry substantial implications for rehabilitation science and physical and rehabilitation medicine. The significant improvements in motivation and movement concept understanding observed in the VR/AR group suggest that immersive technologies are highly effective in cultivating the psychological and cognitive prerequisites for sustained engagement in physical activity factors equally critical in rehabilitation populations. Patient motivation and comprehension of movement principles are recognised as key determinants of functional recovery outcomes in physiotherapy and rehabilitation medicine. Technologies that demonstrably enhance these constructs in healthy adolescent populations may therefore be adapted and deployed in therapeutic contexts to optimise rehabilitation adherence and effectiveness. Furthermore, the movement competence gains associated with immersive technology-based learning align closely with the goals of motor rehabilitation: both contexts require accurate perception of movement, understanding of biomechanical principles, and practice of motor sequences in progressively challenging environments. The ecological validity of technology-simulated movement environments has been demonstrated in clinical rehabilitation research, and the present study extends this evidence base to the educational context, suggesting a translational continuum from school-based physical education to rehabilitation practice. The data-driven feedback capabilities inherent in digital learning platforms also closely parallel the real-time, personalised feedback mechanisms central to evidence-based rehabilitation practice, cultivating digital health literacy and familiarity with technology-assisted monitoring that are increasingly relevant in patient-centred healthcare contexts. Future research should therefore explicitly test the rehabilitation transferability of technology-based motor learning interventions, including studies involving populations with motor impairments and older adults engaged in restorative movement programmes.

b. Implications for Disability Prevention and Functional Health Promotion

From a public health and preventive medicine perspective, technology-supported physical education that enhances motivation and movement competence during adolescence represents a viable strategy for disability prevention and healthy ageing. Populations who develop and maintain high levels of physical competence and intrinsic motivation for movement are substantially less likely to experience premature functional decline, activity-related injury, or chronic disability. The scalability of technology-integrated physical education programmes makes them particularly attractive as population-level preventive health interventions. Students who develop strong intrinsic motivation for physical activity during formative schooling years are better positioned to maintain active lifestyles in adulthood, reducing long-term risks associated with sedentary behaviour, non-communicable disease, and functional decline. These findings therefore position technology-enhanced physical education not merely as a pedagogical innovation, but as a meaningful upstream contributor to functional health promotion across the lifespan an area of growing relevance to rehabilitation medicine, healthy ageing research, and preventive healthcare policy.

Overall, the present findings reinforce that immersive technology-based learning is an effective approach to enhancing both motivation and movement understanding in physical education. Technology integration not only increases student engagement but deepens the quality of movement comprehension and supports optimal learning outcomes effects with meaningful implications for functional health promotion and the prevention of movement-related functional decline in the context of modern, technology-supported education.

5. Conclusions

This study demonstrates that VR/AR-integrated physical education significantly enhances both motivation and movement concept understanding among junior high school students, with the experimental group showing substantially greater gains than the conventionally instructed control group. These improvements in motivational engagement and cognitive understanding of movement represent more than educational achievements: they constitute foundational competencies for long-term physical function, movement adherence, and health-related behaviour. Students who develop strong motor competence and intrinsic motivation for physical activity during formative schooling years are better positioned to maintain active lifestyles, reducing risks of functional decline and supporting healthy ageing trajectories. From a rehabilitation and functional health perspective, the findings indicate that immersive technologies such as VR and AR hold significant promise as tools for technology-supported movement interventions. The capacity of these technologies to create realistic, engaging motor learning environments closely mirrors their emerging applications in rehabilitation settings, where VR/AR is increasingly used for motor recovery, functional assessment, and disability prevention. The motivational effects observed in this study further suggest that such technologies may enhance patient adherence to movement-based rehabilitation programmes. In summary, technology-based innovative learning in physical education contributes positively not only to immediate educational outcomes but also to the broader goals of movement competence development, prevention of functional decline, and promotion of lifelong physical health areas of direct relevance to rehabilitation medicine and functional health science. Future research should focus on longitudinal evaluation of these effects, including motor skill retention, physical activity maintenance, and functional performance indicators, to more fully establish the rehabilitation and preventive health implications of immersive technology integration in physical education.

6. Recommendation

Study furthermore recommended for expand coverage study with involving amount more participants big as well as context more education diverse, so that results study can own level more generalization high. In addition, the development study can direct at the study other relevant variables, such as motor skills, engagement learning, as well as results Study term long, in order to obtain greater understanding comprehensive about impact learning-based technology in education physical. Research can be focused on exploration use type more technology specific in learning, so that the effectiveness of each technology can analyzed in a way deeper. Besides that, use design further research complex, including mixed methods approach, can considered for give a clearer picture intact, good from aspect quantitative and qualitative.

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