ORIGINAL ARTICLE

Innovation in metaverse virtual reality technology and gamification physical education learning styles on students' motor skills

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ABSTRACT

The study integrates information technology into physical education teaching. It used a mixed-method with a quasi-experimental method. The study was conducted on 30 students at Elementary School Jeruk 1 Surabaya. Since the participants came from three different class groups previously, different teaching methodologies were employed for each group: the teaching style was given to the control group, and in experiment 1, the treatment with physical education teaching style and gamification provided. The experiment 2 group was treated using virtual reality. The results of the research showed that virtual reality and exergames provide a relaxed and enjoyable learning environment. However, the study indicates that a well-structured 6-week virtual reality program can significantly improve motor coordination, coordination, and reaction time results for students of Elementary School Jeruk 1 Surabaya. Data from the 7 m single-legged run test had a T result of (p < .012), the 9 m two-way run test showed VR+G results (p < .001), the lateral jumps test had a G result (p < .004), the left-hand handgrip test had a G result of (p < .003), the plate-tapping test had a G result of (p < .003), and the flamingo test had a G result of (p < .01). Gamification is highly favoured by elementary school students compared to the PTS group.

Keywords: Physical education, Metaverse, Gamification, Motor skills.

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INTRODUCTION

In recent years, the development of education as well as the reforms and openness have become very important in the education system. One of the main issues is that students find it difficult to perform motor tasks during physical education learning. Therefore, urgent problems in physical education include single teaching methods, lack of teaching style capabilities, lack of innovation in learning, and lack of comprehensive technical analysis (Castillo, 2018). This methodology increases motivation and facilitates the teaching and learning process (Muntaner Guasp et al., 2020). Latest methodologies, particularly gamification, have emerged and gained relevance in recent years and have been widely used in the field of education (Klock et al., 2020). In this environment, the most important game elements are to be included in education. Although the use of gamification has been shown to increase students' motivation and physical fitness (Ferriz-Valero et al., 2020), its impact on learning improvements remains unclear (Robson et al., 2015). This is most likely due to the lack of research in the field of education, particularly in sports (Fernandez-Rio et al., 2020). The results of the study (Utamayasa & Mardhika, 2024) showed a significant positive impact of virtual reality technology on students' motor development and confidence in performing movements compared to traditional learning.

Conversely, virtual reality and gamification have become relevant in various fields of education and have been quickly adopted for different purposes. This study introduces the application of metaverse-based virtual reality in teaching activities and then uses this technology to build a sports teaching system. Based on this, one effort to help primary schools not struggle in translating motor tasks during learning is to have an approach that can bridge this gap by implementing metaverse virtual reality and gamification. The study showed that using virtual reality applications boosts primary schools' confidence during learning activities and helps students who have low performance. Therefore, physical education teachers must make changes in terms of techniques, motor skills practice, and traditional teaching models that can no longer be used (Liang et al., 2023).

The number of studies published on the use of this technology for educational purposes continues to increase. Educational institutions are now moving quickly to adopt virtual reality as an educational and training tool because it can be directly applied to the teaching and learning process, resulting in positive learning outcomes across various domains (Kavanagh et al., 2017). This process offers real-time multisensory feedback during task-oriented training, thus facilitating motor learning. This opens up opportunities for the development of a virtual reality and gamification physical education system, injecting new scientific elements into the modernization of physical education. Virtual reality technology can be used in learning and has proven effective in the development of physical education (Martins et al., 2012).

This study introduces for the first time the application of metaverse virtual reality and gamification in teaching styles in these activities and then uses this technology to build a sports teaching system. Next, we analyse the importance of integrating it into teaching models. This study shows that the new teaching model has a good effect on improving teaching quality. This study advances a technology-based physical education teaching model. In the field of physical education, interest and demand for virtual reality-based learning activities are increasing and are currently being developed (Gurrin et al., 2014). Similarly, it is necessary to investigate how children perceive effort, motivation, compliance, and satisfaction when undergoing virtual reality activities during sports lessons in a school environment (Polechoński et al., 2020), considering some differences in the literature reporting significant learning outcomes when comparing virtual reality with other active learning or traditional learning methods (Moro et al., 2020). In addition, previous research on the use of virtual reality in physical education is still lacking compared to other methodologies. Therefore, this study

aims to analyse the effect of using virtual reality and gamification in physical education learning styles on students' motor skills and perceived efforts.

Using the designed technology, advantages in physical education will prominently provide an effective learning environment. New technology reforms promote the application of the metaverse in sports teaching. Research shows that a teaching environment that uses this new technology can attract more students to participate in sports activities. The study on the application of metaverse-based virtual reality and gamification in physical education teaching is relatively detailed. The application of this technology helps schools successfully carry out sports activities. It can be concluded that using this technology can enhance students' learning outcomes (Yu & Mi, 2023). Additionally, based on these findings, by presenting a physical education model that integrates metaverse and gamification technology, this study intends to suggest metaverse-based physical education as a new alternative. Therefore, physical education will also be one of the beneficiaries of metaverse technology (Yu & Mi, 2023). Teachers must implement more advanced metaverse technology and concepts to refine and complement current physical education.

The state of the art of this research is viewed from the problem of practical physical education learning styles, where teachers mostly demonstrate tasks and students only practice the tasks given by their teachers. Therefore, the learning style becomes monotonous and students are less active in the learning process. Thus, the learning style can be replaced with a more active, engaging methodology and student-centred options that encourage students' participation and engagement in improving motor skills. Previous research has used augmented reality-based technology in the learning process. Augmented reality is another virtual technology that has been shown to enable students to enhance performance by considering different dimensions, facilitating the understanding of theoretical parts, and accelerating the development of students' motor skills (Moreno-Guerrero et al., 2020). Additionally, the use of digital *book creators* has also been used to enhance students' motor skills (Hasanah, 2021). Other studies also state that the use of video-based visuals has been used in physical education learning to improve students' motor skills (Mödinger et al., 2022).

The novelty of this study lies in demonstrating the capacity of virtual reality and gamification on physical education learning styles to enhance children's motor competence. The benefits of motor skills in physical education learning help physical activities and can positively impact students' cognitive, social, and emotional development. Based on this reality, one effort to help primary schools not struggle with motor tasks during learning is to have an approach that can bridge this gap by implementing metaverse virtual reality and gamification in physical education learning styles.

MATERIAL AND METHODS

This study integrates information technology into physical education teaching. The study design uses a *mixed-method* with a quasi-experimental method. Qualitative data were collected after virtual reality and gamification interventions to find mechanisms that potentially explain quantitative results (Fetters et al., 2013). This study was conducted on students at Sekolah Dasar N Jeruk 1 Surabaya, totalling 30 students. Therefore, considering that the participants came from three different class groups previously, different teaching methodologies were allocated for each group: a teaching style was given to the control group, and experiment 1 was given physical education and gamification teaching styles. Experiment 2 was treated using virtual reality. For qualitative data, to meet the research objectives, motor skills and perceived effort were qualitatively explored through two steps: first, semi-structured individual interviews and group discussions.

The procedures in this study are:

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1. In the initial stages, participants were evaluated before and after the intervention, consisting of two weekly sports sessions each lasting 50 minutes for six weeks.
2. To evaluate motor skills, the *sportcomp* motoric test was described and validated by Ruiz-Perez (Morillo-Baro et al., 2015). It consists of 5 motor skills tests including: 7 m run with both feet together, 7 m run with one foot, lateral jump, 9 m two-way run, and transfer with support. Each participant performed three trials on each side, and the highest average score was taken as the result. The next test recommendation is the balance test (Rami & Prabhakar, 2018). Participants followed the research procedure by signing a consent form. All procedures comply with the research ethics code.
3. The three groups followed the research procedure. Gamification was developed and designed during the intervention with the underlying context of the film Avatar 2. Researchers provided an introductory video to students before the intervention connecting various activities with this theme. In the gamification group, students were divided into four groups. Explanations about the scores they could achieve in each activity were given, and at the end of each session, each group could exchange these points for game cards that could be used in the next session.
4. The virtual reality group had special treatments equipped with glasses and Kinect Sports Xbox. VR technology training (20 minutes/session; 2 sessions per week; total 6 weeks; total 240 minutes/participant. The commercial VR training video game used was Just Dance 2022. Data collection before and after the intervention was carried out by researchers, under the supervision and support of the teacher.

Data are presented as ± standard deviation, sampling estimation was carried out using G*Power 3.1.9.7 software. Statistical analysis was performed using Jamovi software for Windows, version 2.3.12. Repeated measures ANOVA tests were conducted to analyse the effect of the teaching methodology on related variables. The expected results of this study are that using virtual reality and gamification applications make students confident during the learning activities and help students with low performance. This study aims to analyse the effect of using virtual reality and gamification in physical education learning styles on students' motor skills and perceived effort.

The document mentions that the study involved 30 students (15 female and 15 males; aged 7–12 years) from Sekolah Dasar Negeri 1 Jeruk Surabaya. Using this information, I can format the demographic data into Table 1.

Table 1. Characteristics of the participants.

Characteristic	**Number (n)**	**Percentage (%)**
Total participants	30	100
Gender		
- Male	15	50
- Female	15	50
Age group		
- 7–9 years	10	33.3
- 10–12 years	20	66.6

The data collection technique in this mixed-method study uses the *concurrent embedded* model, where quantitative and qualitative data collection is carried out simultaneously, and alternately within a short time interval. Quantitative data collection techniques are the main focus of the research by providing instruments that have been tested for validity and reliability to the entire sample. Qualitative data collection techniques

are carried out with in-depth interviews, documentation, and extensive use of observations and data collection using a natural setting. Data analysis uses descriptive statistics.

RESULTS

The study involved 30 students at Sekolah Dasar Negeri 1 Jeruk Surabaya, Indonesia. A total of 30 students (15 female and 15 males; average age 7-12 years). The results are reported in the following order: (a) quantitative and intervention results, (b) qualitative results, and (c) mixed methods (integration).

Quantitative findings

Table 2. Findings from the study. Results are presented as mean ± SD.

		Pre-Intervention			Post-Intervention			*p*
7 m feet-together run test	VR+G	3.12	±	0.43	3.33	±	0.45	3.23
	G	3.67	±	0.56	3.78	±	0.54	0.023
	T	3.20	±	0.67	4.05	±	0.66	0.023
7 m single-legged run test	VR+G	3.02	±	0.45	3.87	±	0.43	0.56
	G	2.70	±	0.44	3.43	±	0.54	0.243
	T	3.01	±	0.66	3.02	±	0.67	0.012**
9 m two-way run test	VR+G	12.02	±	1.23	11.98	±	1.23**	0.001**
	G	12.05	±	1.78	12.04	±	1.34	0.232
	T	12.03	±	1.56	16.8	±	1.09	0.233
Displacement with support test	VR+G	16.7	±	3.37	18.6	±	2.67	2.12
	G	17.9	±	4.56	19.2	±	4.63	0.125
	T	15.6	±	3.87	37.6	±	4.67	0.022
Lateral jumps test	VR+G	30.8	±	6.78	35.5	±	5.09**	45.34
	G	31.6	±	6.56	36.6	±	6.85**	0.004**
	T	32.2	±	8.23	33.6	±	5.94**	0.235
Left-hand handgrip test	VR+G	7.23	±	4.67	23.8	±	6.55**	237.8
	G	7.78	±	5.54	30.6	±	7.66**	0.003**
	T	8.34	±	8.23	34.5	±	9.12	0.764
Plate-tapping test	VR+G	5.07	±	0.65	9.87	±	6.23**	297.6
	G	5.78	±	0.54	10.2	±	8.13	0.003**
	T	6.43	±	0.76	10.7	±	8.56	0.657
Flamingo test	VR+G	11.9	±	1.65	3.56	±	1.43	11.45
	G	11.7	±	2.13	5.66	±	2.21	0.001**
	T	11.4	±	1.54	4.37	±	2.45	0.125

*Note. VR: virtual reality; G: gamification; T: traditional. * Different from pre ($p < .05$); ** Different from pre ($p < .001$).*

In the table above, the 7 m single-legged run test has a T result of ($p < .012$), the 9 m two-way run test shows VR+G ($p < .001$), the lateral jumps test has a G result of ($p < .004$), the left-hand handgrip test has a G result of ($p < .003$), the plate-tapping test has a G result of ($p < .003$), and the flamingo test has a G result of ($p < .01$).

Qualitative findings

There are two main indicator categories identified: (a) perceived effort and (b) improvement in motor skills. These results are supported by narratives obtained from participants. In the specific case of VR activities, no participants stated that activities in the VR field resulted in improvements in their motor skills.

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Mixed method findings

Table 3. Combined quantitative and qualitative results.

Measurement results	Quantitative	Qualitative
PCERT (children's effort ranking table): effort levels between 1 (very, very easy) and 10 (so difficult that you would stop) with an average value of 5 (starting to get difficult)	Students rated perceived effort higher in PTS compared to the other two learning groups (p < .012)	Effort was experienced when performing activities that required continuity. On the other hand, these activities demanded greater mental effort, such as juggling with a ball or those requiring motor control and coordination. Lastly, VR activities did not require much effort from the students.
Motor tests: determine motor coordination in students aged 7-10 years through 5 tests (7 m run, 7 m single-legged run, lateral jump, 9 m two-way run, and transfer with support). Handgrip test, flamingo test. Eurofit: Measures grip strength and balance.	All three groups had interventions in the 7 m single-legged run test T (p < .012) and lateral jumps test (p < .004). Only two GAM groups showed improvement in the left-hand handgrip test (p < .003). Only the PTS learning group scored lower in the transfer movement with the flamingo test (p < .001). The 9 m two-way run test had VR+G (p < .001).	These activities had limited time to show motor improvements. VR activities did not require physical effort and had little impact on improving physical performance in non-virtual environments. What could be improved through VR are activities related to hand-eye coordination and reaction speed.

DISCUSSION

The use of technology that enables the creation of interactive environments and the provision of a form of physical enhancement through the use of exergames via VR. Our study results are similar to other literature studies showing that virtual reality can improve coordination (Barbosa et al., 2020). Statistical analysis indicates that gamification can improve students' motor skills in the lateral jump test. The study results (Zhao et al., 2024) show that exergames can enhance student sports learning and the impact of exergames on student sports learning outcomes. Virtual reality and exergames can provide a relaxed and enjoyable learning environment. The integration of exergames and virtual reality into the physical education teaching style aligns well with student preferences. As a result, students transform from passive and receptive learning habits into spontaneous and active learning, ultimately achieving high-quality physical education learning. In conclusion, exergames align with modern educational concepts aimed at developing students and improving their health quality and social adaptability (Zhao et al., 2024).

From the document provided, the p-values for male and female comparisons in Table 2, Table 3, and Table 4 are not explicitly mentioned as gender-specific comparisons. For the interventions and tests listed, significant differences are reported when the p-value is less than .05. These differences are attributed to group-specific interventions rather than gender comparisons. If you need specific gender-based analysis, the document does not provide separate male vs. female statistical results. Clarification from the study authors or additional statistical analysis might be required to address gender-specific differences. Let me know if you'd like assistance with further analysis or clarifications.

However, this study shows that a well-structured six-week virtual reality program can significantly improve motor coordination, coordination, and reaction time in students at Sekolah Dasar Negeri 1 Jeruk Surabaya. Besides the small number of participants and the relatively short intervention time, this research has other limitations, such as the lack of medium- and long-term verification of subjects' participation in different physical activities. Future studies should focus on these issues. Future technology, especially in physical education, will undoubtedly bring advancements and optimize the combination of virtual reality and exergames experiences. The results show that VR and exergames can significantly improve children's motor skills compared to the control group, consistent with previous studies (Jelsma et al., 2013), which conducted VR training (Nintendo Wii Fit) for 25 minutes, 4 times a week for 3 weeks and found that children's motor function significantly improved.

Meta-analysis results show that gamification and teaching styles using VR positively influence students' motor skills in sports learning (sig < .012), indicating that gamification applications can facilitate student sports learning with statistical significance. The reasons may include the following aspects:

1. Gamification is characterized by fun, flexibility, and competence. Implementing learning styles through gamification can increase participation and learning interest, thereby motivating them to learn actively. Additionally, students gain a sense of accomplishment in completing gamification tasks, further enhancing their confidence in learning (Hu et al., 2022).
2. Gamification using VR can provide a relaxed and enjoyable learning style environment. Students can repeatedly simulate exercises in this environment, creating a stronger sense of participation and actual experience, fully enjoying the fun and charm of sports. Moreover, the learning environment created through games allows students to form a common perception of learning movement techniques.
3. Integrating exergames into sports programs aligns well with student preferences. As a result, students transform from passive, receptive learning habits to spontaneous, active learning, ultimately achieving high learning quality. In conclusion, exergames align with modern educational concepts aimed at developing students and improving health quality and social adaptability (He & Hao, 2014).

VR gamification provides a platform for students to express themselves fully. Through game media, students can confidently display themselves, encouraging strong intrinsic motivation to engage more actively in sports classes. Success rewards in games inspire students to feel pride and satisfaction, gradually boosting their confidence and self-identity, leading to a positive learning attitude, increased exercise frequency, and continuous skill improvement throughout the course. Therefore, gamification strategies should be implemented in student-centred teaching models to promote active learning, collaboration, and problem-solving in constructivist models (Ferraz et al., 2024). Gamification can be presented as a means to induce positive changes in student behaviour by increasing physical activity levels and emotional states, supporting positive attitudes and motivation towards physical activity practices (Goodyear et al., 2021). There is growing interest in gamification among teachers and educational institutions (Figueroa Flores, 2016). Using games in this context has proven to have a significant impact according to research conducted by (Liu & Lipowski, 2021). Therefore, it is crucial to analyse the educational context and design appropriate gamification tailored to specific students. A novel aspect of this review is that virtual reality is highly suitable for incorporating motor learning principles.

Exergames and VR positively impact elementary school students by providing positive emotional experiences and enjoyment, thus enhancing their intrinsic motivation for physical activity (Hou & Li, 2022) (Bae, 2023). Additionally, it has been observed that VR involves specific motor and cognitive skills and the ability to optimize desired movement trajectories (Dong et al., 2023), highlighting its interest in developing and

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enhancing motor skills. Participants in this study may not have perceived such improvements due to the short intervention duration or the insensitivity of the measurement outcomes used.

This is evidenced by the improvement in the lateral jump test in both GAM study groups compared to the PTS study group ($p < .004$). Additionally, the PTS study group, along with the PTS group, showed a decline in post-intervention support transfer test performance ($p < .235$), possibly due to the speculative lack of motivation in this group compared to the GAM group and not due to deteriorating motor skills. Although the impact of GAM on sports motivation is beyond this study's scope, motivation can also be considered a potential determinant of participants' perceived effort, which was interestingly rated lower by both GAM study groups. Based on qualitative results, some participants did not perceive VR activities as demanding, indicating a disruptive effect of VR on the PTS+GAM+VR group. Additionally, significantly lower perceived effort in both GAM groups (combined with or without VR) coincides with participants' relative perception of effort regarding activity type and participation format (Criollo-C et al., 2024). VR and Gamification can enhance education quality and active student participation. This study presents several noteworthy strengths. Firstly, this research is easily applicable and implementable in the educational context of elementary school children.

CONCLUSIONS

Gamification is highly favoured by elementary school children compared to the PTS group. When combined with VR, it can enhance elementary school children's motor skills. As educational and societal needs and demands change, traditional learning needs to be reinforced and transformed through new technology applications and approaches to adapt and meet new needs. The use of gamification and virtual reality in physical education is becoming more popular as a means to satisfy students' desire for more interactive, immersive, engaging, and meaningful learning. Based on the results, gamification can positively influence educational activities and enrich virtual reality experiences to create a more interactive, engaging, and motivating learning environment. Most studies report positive results regarding improving motor skills and student satisfaction. Both students and teachers positively assess its usefulness in education, highly appreciating its role in transforming traditional teaching and learning activities and highly valuing the benefits it can bring to the educational process by facilitating and supporting teachers and successfully meeting students' needs and demands for more effective learning benefits.

AUTHOR CONTRIBUTIONS

Design of the Study, IGDU and AIK; Data Gathering, LPTU; Statistical Evaluation, IGDU; Data interpreting, AIK; Writing of the Manuscript, IGDU and AIK; Search of the Literature, AIK and LPTU. Each author has reviewed the final draft of the manuscript and given their approval.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

ETHICS STATEMENT

This research followed ethical standards and received approval from the Institutional Ethical Committee Universitas PGRI Adi Buana Surabaya numbered 165.7 / ST / LPPM / XI / 2024 dated 15 November 2024.

REFERENCES

Bae, M.-H. (2023). The Effect of a Virtual Reality-Based Physical Education Program on Physical Fitness among Elementary School Students. Iranian Journal of Public Health, 52(2), 371-380. https://doi.org/10.18502/ijph.v52i2.11890

Barbosa, E., Barbosa, E., Frankly, D., Sales, O., Pimentel, D., Vaghetti, C., Carneiro, L., Rodrigues-Sobral, M., & Monteiro-Junior, R. (2020). Virtual Reality-Based Exercise Reduces Children's Simple Reaction Time. International Journal of Sports Science, 112-116.

Castillo, M. (2018). Origen y desarrollo de las metodologías activas dentro del sistema educativo español. Encuentro Journal, 27, 4-21. https://doi.org/10.37536/ej.2018.27.1890

Criollo-C, S., Guerrero-Arias, A., Guaña-Moya, J., Samala, A. D., & Luján-Mora, S. (2024). Towards Sustainable Education with the Use of Mobile Augmented Reality in Early Childhood and Primary Education: A Systematic Mapping. Sustainability (Switzerland), 16(3). https://doi.org/10.3390/su16031192

Dong, Y., Liu, X., Tang, M., Huo, H., Chen, D., Du, X., Wang, J., Tang, Z., Qiao, X., Guo, J., Fan, L., & Fan, Y. (2023). Age-related differences in upper limb motor performance and intrinsic motivation during a virtual reality task. BMC Geriatrics, 23(1), 1-11. https://doi.org/10.1186/s12877-023-03970-7

Fernandez-Rio, J., Heras, E., Gonzalez, T., Trillo, V., & Palomares, J. (2020). Gamification and physical education. Viability and preliminary views from students and teachers. Physical Education and Sport Pedagogy, 1-16. https://doi.org/10.1080/17408989.2020.1743253

Ferraz, R., Ribeiro, D., Alves, A. R., Teixeira, J. E., Forte, P., & Branquinho, L. (2024). Using Gamification in Teaching Physical Education: A survey review. Montenegrin Journal of Sports Science and Medicine, 20(1), 31-44. https://doi.org/10.26773/mjssm.240304

Ferriz-Valero, A., Østerlie, O., García Martínez, S., & García-Jaén, M. (2020). Gamification in Physical Education: Evaluation of Impact on Motivation and Academic Performance within Higher Education. International Journal of Environmental Research and Public Health, 17, 4465. https://doi.org/10.3390/ijerph17124465

Fetters, M. D., Curry, L. A., & Creswell, J. W. (2013). Achieving integration in mixed methods designs-principles and practices. Health Services Research, 48(6 Pt 2), 2134-2156. https://doi.org/10.1111/1475-6773.12117

Figueroa Flores, J. (2016). Gamification and Game-Based Learning: Two Strategies for the 21st Century Learner. World Journal of Educational Research, 3, 507. https://doi.org/10.22158/wjer.v3n2p507

Goodyear, V., Skinner, B., Mckeever, J., & Griffiths, M. (2021). The influence of online physical activity interventions on children and young people's engagement with physical activity: a systematic review. Physical Education and Sport Pedagogy, 28, 1-15. https://doi.org/10.1080/17408989.2021.1953459

Gurrin, C., Smeaton, A. F., & Doherty, A. R. (2014). LifeLogging: Personal Big Data Foundations and Trends R in Information Retrieval. Information Retrieval, 8(1), 1-107. https://doi.org/10.1561/1500000033

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Hasanah, S. (2021). Strategi Pembelajaran Pendidikan Jasmani Berbantu Media Book Creator Digital Dalam Meningkatkan Kemampuan Motorik Kasar Siswa Pada Tingkat Sekolah Dasar. Continuous Education: Journal of Science and Research, 2, 23-35. https://doi.org/10.51178/ce.v2i2.225

He, Z., & Hao, G. (2014). Physical Education Reform and Development in Regular Institutions of Higher Learning under the Vision of Modern Great Education. Advances in Physical Education, 04, 36-40. https://doi.org/10.4236/ape.2014.41006

Hou, H.-Y., & Li, H.-J. (2022). Effects of exergame and video game training on cognitive and physical function in older adults: A randomized controlled trial. Applied Ergonomics, 101, 103690. https://doi.org/10.1016/j.apergo.2022.103690

Hu, Y., Gallagher, T., Wouters, P., Schaaf, M. F., & Kester, L. (2022). Game-based learning has good chemistry with chemistry education: A three-level meta-analysis. Journal of Research in Science Teaching, 59. https://doi.org/10.1002/tea.21765

Jelsma, J., Pronk, M., Ferguson, G., & Jelsma-Smit, D. (2013). The effect of the Nintendo Wii Fit on balance control and gross motor function of children with spastic hemiplegic cerebral palsy. Developmental Neurorehabilitation, 16(1), 27-37. https://doi.org/10.3109/17518423.2012.711781

Kavanagh, S., Luxton-Reilly, A., Wuensche, B., & Plimmer, B. (2017). A Systematic Review of Virtual Reality in Education, Themes in Science and Technology Education, 2017. Themes in Science & Technology Education, 10(2), 85-119.

Klock, A., Gasparini, I., Pimenta, M., & Hamari, J. (2020). Tailored gamification: A review of literature. International Journal of Human-Computer Studies, 144, 102495. https://doi.org/10.1016/j.ijhcs.2020.102495

Liang, L., Zhang, Z., & Guo, J. (2023). The Effectiveness of Augmented Reality in Physical Sustainable Education on Learning Behaviour and Motivation. Sustainability, 15(6), 5062. https://doi.org/10.3390/su15065062

Liu, T., & Lipowski, M. (2021). Sports gamification: Evaluation of its impact on learning motivation and performance in higher education. International Journal of Environmental Research and Public Health, 18(3), 1-12. https://doi.org/10.3390/ijerph18031267

Martins, V. F., Abreu, F. R., Militino, R., Fukuoka, S., & Guimarães, M. D. P. (2012). Estratégia de Desenvolvimento, Implantação e Avaliação do uso da Realidade Virtual na Educação: Estudo de Caso na área de Português. Anais Do Simpósio Brasileiro de Informática Na Educação, 23(1), 26-30. Retrieved from [Accessed 2025, February 13]: http://www.br-ie.org/pub/index.php/sbie/article/view/1721

Mödinger, M., Woll, A., & Wagner, I. (2022). Video-based visual feedback to enhance motor learning in physical education-a systematic review. German Journal of Exercise and Sport Research, 52(3), 447-460. https://doi.org/10.1007/s12662-021-00782-y

Moreno-Guerrero, A.-J., Alonso García, S., Ramos Navas-Parejo, M., Campos-Soto, M. N., & Gómez García, G. (2020). Augmented Reality as a Resource for Improving Learning in the Physical Education Classroom. International Journal of Environmental Research and Public Health, 17(10). https://doi.org/10.3390/ijerph17103637

Morillo-Baro, J. P., Reigal, R. E., & Hernández-Mendo, A. (2015). Análisis del ataque posicional de balonmano playa masculino y femenino mediante coordenadas polares. RICYDE: Revista Internacional de Ciencias Del Deporte, 11(41), 226-244. https://doi.org/10.5232/ricyde

Moro, C., Phelps, C., Redmond, P., & Štromberga, Z. (2020). HoloLens and mobile augmented reality in medical and health science education: A randomised controlled trial. British Journal of Educational Technology, 52. https://doi.org/10.1111/bjet.13049

Muntaner Guasp, J. J., Pinya Medina, C., & Mut Amengual, B. (2020). The impact of active methodologies in academic results: A case study. Profesorado, 24(1), 96-114. https://doi.org/10.30827/profesorado.v24i1.8846

Polechoński, J., Nierwińska, K., Kalita, B., & Wodarski, P. (2020). Can Physical Activity in Immersive Virtual Reality Be Attractive and Have Sufficient Intensity to Meet Health Recommendations for Obese Children? A Pilot Study. International Journal of Environmental Research and Public Health, 17(21). https://doi.org/10.3390/ijerph17218051

Rami, P., & Prabhakar, M. (2018). Comparison of Static Balance in Male Football and Basketball Players by Using Flamingo Balance Test. International Journal of Physiotherapy, 5. https://doi.org/10.15621/ijphy/2018/v5i5/177432

Robson, K., Plangger, K., Kietzmann, J., McCarthy, I., & Pitt, L. (2015). Is it all a game? Understanding the principles of gamification. Business Horizons. https://doi.org/10.1016/j.bushor.2015.03.006

Utamayasa, I. G. D., & Mardhika, R. (2024). An innovative approach in physical education: Exploring the impact of interactive virtual reality on motor skills. Edu Sportivo: Indonesian Journal of Physical Education, 5(1), 1-9. https://doi.org/10.25299/esijope.2024.vol5(1).14354

Yu, H., & Mi, Y. (2023). Application Model for Innovative Sports Practice Teaching in Colleges Using Internet of Things and Artificial Intelligence. Electronics (Switzerland), 12(4). https://doi.org/10.3390/electronics12040874

Zhao, M., Lu, X., Zhang, Q., Zhao, R., Wu, B., Huang, S., & Li, S. (2024a). Effects of exergames on student physical education learning in the context of the artificial intelligence era: a meta-analysis. Scientific Reports, 14(1), 1-10. https://doi.org/10.1038/s41598-024-57357-8

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