JOSSAE (Journal of Sport Science and Education)

OPEN ACCESS
E-ISSN Online: 2548-4699
http://journal.unesa.ac.id/index.php/jossae/index
http://dx.doi.org/10.26740/ jossae.v11n1.p1-11

Augmented Reality for Inclusive Physical Education: Development and Evaluation of Disability-Based Movement Adaptation Simulations

Merlina Sari[1ABCDE]*, Novia Nazirun[2CD], Yoyon Efendi[3CD], Novri Gazali[4BCD], Nagoor Meera Abdullah[5CD]
[1,2,4] Universitas Islam Riau, Indonesia
[3] Universitas Sains dan Teknologi Indonesia
[5] Universiti Teknologi MARA, Malaysia

*Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Correspondence: merlinasaripenjas@edu.uir.ac.id
Received: 02 Feb 2026 **Accepted**: 27 Apr 2026 **Published**: 30 Jul 2026

Abstract
Adaptive physical education requires prospective teachers to have adaptive pedagogical competencies to respond to the diversity of students with disabilities. However, limited practical learning experiences in higher education often hinder students' understanding of movement adaptation. This study aims to develop and evaluate an augmented reality (AR) application as a simulation medium for movement adaptation based on disability types in adaptive physical education learning. A research and development approach was employed using the Multimedia Development Life Cycle (MDLC) model. The participants consisted of 30 physical education students selected purposively. The instruments included expert validation sheets, user practicality questionnaires, and movement adaptation comprehension tests. Data were analyzed descriptively and inferentially using a paired-sample t-test and effect size analysis. The results indicated that the AR application was valid (M = 4.28; 85.5%) and practical to use (M = 4.38; 87.5%). Furthermore, there was a significant improvement in students' understanding of movement adaptation from pretest (M = 68.40, SD ≈ 6.00) to posttest (M = 82.60, SD ≈ 5.80), with a mean difference of 14.20 points. The improvement was statistically significant ($p < 0.001$) with a large effect size (Cohen's $d > 0.80$). These findings demonstrate that the AR application is effective in enhancing students' understanding of disability-based movement adaptation. Thus, the application has strong potential as an innovative learning medium to support the development of adaptive pedagogical competencies among prospective physical education teachers.

Keywords: Adaptive physical education; augmented reality; disability; experiential learning; inclusive education

1. Introduction

Overweight is a growing global health concern and a critical precursor to obesity, a condition now classified as a multisystem disease (Garvey & Mechanick, 2020; Sarma et al., 2021). Individuals with overweight status face elevated risks of developing metabolic complications, including insulin resistance, dyslipidemia, hypertension, and cardiovascular disease, which intensify significantly if overweight progresses to obesity (Khalafi et al., 2024). In Indonesia, the prevalence of overweight and obesity continues to rise (Sholikhah & Tuah, 2021), with national health data indicating an urgent need for early intervention strategies to prevent this progression (Kementrian Kesehatan RI, 2023; Nugraha, 2022). Therefore, targeting body fat reduction at the overweight stage is essential to mitigating long-term health risks before the onset of obesity-related complications (Harris et al., 2018).

A primary contributor to excess body fat accumulation is energy imbalance resulting from high-calorie diets and insufficient physical activity (Cena & Calder, 2020; Conde-Pipó et al., 2024; Khalafi et al., 2024). Physical exercise encompassing aerobic modalities such as jogging and anaerobic modalities such as weight training (WT) has been shown to effectively reduce body fat when combined with dietary regulation (Hita, 2020; Jia et al., 2022; Nugraha et al., 2020; Park et al., 2020; Zouhal et al., 2020). Among dietary strategies, intermittent fasting (IF) has gained considerable attention due to its effectiveness in reducing body weight by more than 5% and improving metabolic health markers in overweight and obese populations (Naous & Achkar, 2023; Varady et al., 2021). Research further confirms that IF is more effective when combined with physical exercise: (Khalafi et al., 2024) demonstrated that combining exercise training with IF yields superior improvements in body composition compared to either intervention alone, while (Gabel et al., 2025) highlighted the synergistic metabolic benefits of this combination.

Although previous studies have demonstrated the independent and combined effects of intermittent fasting and exercise on body composition, limited evidence directly compares aerobic exercise and resistance-based training when both are combined with intermittent fasting and calorie restriction in overweight young men (Domaszewski et al., 2020; Khalafi et al., 2024; Naous & Achkar, 2023). Most existing research has examined either aerobic or resistance training in isolation with IF, without a head-to-head comparison of these two exercise modalities under equivalent dietary conditions.

Therefore, this study aims to examine the effects of combining aerobic exercise with IF, combining anaerobic exercise with IF, and comparing the effectiveness of both methods in reducing body fat levels among overweight male university students. More specifically, this study focuses on three main research questions, namely: (1) how does the combination of jogging and IF affect body fat levels, (2) how does the combination of WT and IF affect body fat levels, and (3) is there a significant difference in the effect between the combination of jogging + IF and WT + IF in reducing body fat levels?

2. Method

Research Design

The method used in this study utilises marker-based tracking, an augmented reality technique that enables the creation of interactive and user-friendly learning media (Pangestu et al., 2020).The development of this application adopts the Multimedia Development Life Cycle method, which is a structured and sequential multimedia development method (Nabila & Sundari, 2024). MDLC involves six stages, including concept, design, material collecting, assembly, testing, and distribution (Iqbal et al., 2022).

The MDLC approach was chosen because it is in line with the research objectives, which focus on the development of immersive technology-based learning media, while also allowing for systematic evaluation of the validity, practicality, and effectiveness of the resulting product. This study employed a research and development (R&D) design, focusing on constrained trials involving the target demographic, specifically prospective physical education teacher students.

Participants

The participants in this study were 30 students majoring in physical education at universities who had taken or were currently taking adaptive physical education courses. Participants were selected using purposive sampling, considering their role as prospective teachers developing adaptive pedagogical competencies in inclusive physical education contexts. A priori power analysis was conducted to justify the adequacy of the sample size. Using a medium effect size ($d = 0.50$), significance level ($\alpha = 0.05$),

and statistical power of 0.80, the minimum required sample size was estimated to be approximately 27 participants. Therefore, the sample size of 30 participants in this study was considered sufficient to detect statistically significant effects.

The research was conducted in adaptive physical education classes at universities, focusing on improving students' understanding of movement adaptations based on disability types, including physical, sensory, intellectual, and autism spectrum disorders. Inclusion and exclusion criteria are presented in Table 1.

Table 1. Inclusion and Exclusion Criteria for Participant

Category	Criteria
Inclusion	1) Active students in the Physical Education Study Program; 2) Have taken or are currently taking adaptive physical education courses; 3) Have basic experience in using digital devices (smartphones or tablets); 4) Are willing to participate in all stages of the research and provide informed consent.
Exclusion	1) Students who have never taken adaptive physical education courses; 2) Students who do not participate in the entire series of application trials; 3) Students who have significant technical difficulties in using AR devices, thereby hindering their participation in the research.

Application Development Procedure

The research procedure follows the six stages of the Multimedia Development Life Cycle (MDLC), namely concept, design, material collecting, assembly, testing, and distribution. In the concept stage, learning needs are analysed through a literature review and discussions with lecturers to determine the learning objectives, types of disabilities, and forms of movement adaptation simulated in the AR application. The design stage includes designing the application flow, storyboard, user interface, marker-based tracking scheme, and learning indicators, taking into account usability principles. The material collecting stage involves collecting supporting materials in the form of adaptive movement references, images, videos, three-dimensional models, and audio narratives that are relevant and based on scientific studies. Furthermore, in the assembly stage, all materials are integrated into the AR application through the development of virtual objects and marker-based interaction settings, accompanied by initial functional testing. The testing stage is conducted to assess the validity of the content, practicality, and limited effectiveness of the application through expert assessment and user responses. The final stage, distribution, includes the provision of the application and user guidelines to support its implementation in adaptive physical education learning in higher education.

Instruments

The research instruments consisted of an expert validation sheet, a user practicality questionnaire, and a motion adaptation comprehension test, which are commonly used in research and development of technology-based learning media (Laksana, 2024). The reliability of the instruments was assessed using Cronbach's alpha, with a threshold value of $\alpha \geq 0.70$ indicating acceptable internal consistency. Content validity was evaluated using the Content Validity Index (CVI), calculated based on expert ratings, where CVI values ≥ 0.80 indicate adequate content validity. The expert validation sheet assessed the suitability of application content with adaptive physical education principles. The practicality questionnaire measured usability aspects such as ease of use, clarity, and usefulness. The comprehension test evaluated students' understanding of disability-based movement adaptation.

Data Analysis

The research data were analysed descriptively and inferentially to evaluate the validity, practicality, and effectiveness of the augmented reality application. Expert validation and practicality data were analysed using mean scores and percentages. Inferential analysis was conducted using a paired-sample t-test to examine differences between pretest and posttest scores. Effect size was calculated using Cohen's d to determine the magnitude of the intervention effect.

3. Result

The results of the study are presented based on three main aspects of evaluating augmented reality applications: content validity, practicality of use, and learning effectiveness.

Augmented Reality Application Development Results

The augmented reality application developed was successfully implemented on Android devices and designed to simulate movement adaptation based on the type of disability in the context of adaptive physical education. The application provides a menu for selecting the type of disability, which includes sensory disabilities (speech, hearing, and visual), physical disabilities, intellectual disabilities, and mental disabilities.

As shown in **Figure 1**, the application interface displays a main menu that allows users to select the type of disability to start the AR experience. After selecting the disability category, users are directed to a marker-based tracking simulation display that displays three-dimensional virtual objects and contextual information related to disability characteristics and their implications for physical education movement activities. Furthermore, **Figure 2** shows an example of the visualisation of motion adaptation simulations for physical disabilities, such as the use of wheelchairs and walking aids. This visualisation is designed to help students understand mobility limitations and the need for modifications to motion activities in adaptive physical education. Users can operate all application features interactively via an Android device, enabling them to independently explore motion adaptation simulations.

Figure 1. Display of the Disability Type Selection Menu on the Augmented Reality Application

Figure 2. Augmented Reality Simulation

Content Validity of the Application

The results of expert validation show that the augmented reality application developed has a high level of content validity. As shown in **Table 2**, the overall average expert assessment score reached 4.28 with a feasibility percentage of 85.5%, which is classified as valid. This assessment indicates that the simulated movement adaptation content in the application is in accordance with the principles of adaptive physical education and the characteristics of the type of disability that is the focus of learning.

In more detail, the display and visual quality aspect received the highest score (M = 4.35; 87.0%), followed by the suitability of the movement adaptation content (M = 4.30; 86.0%). Meanwhile, the accuracy of disability simulation remained in the valid category despite receiving a relatively lower score compared to other aspects (M = 4.20; 84.0%). These findings indicate that, overall, the application has met the content feasibility standards for use in adaptive physical education learning, as shown in **Table 2**.

Table 2. Results of application content validation by experts

Assessment Aspects	Average Score	Percentage (%)	Category
Appropriateness of movement adaptation content	4.30	86.00	Valid
Clarity of learning objectives	4.25	85.00	Valid
Accuracy of disability simulation	4.20	84.00	Valid
Display and visual quality	4.35	87.00	Valid
Overall average	**4.28**	**85.50**	**Valid**

Practicality of Use

The practicality of the application was evaluated based on student responses after using it for learning. The results of the analysis show that the application is in the practical category, as shown in **Table 3**. The overall average practicality score reached 4.38 with a percentage of 87.5%, indicating a high level

of user acceptance. Students rated the aspect of learning usefulness as the highest scoring aspect (M = 4.45; 89.0%), followed by the ease of use of the application (M = 4.40; 88.0%). The aspect of augmented reality interaction also received a high score (M = 4.30; 86.0%), indicating that marker-based tracking technology can function well in a learning context. **Table 3** displays detailed scores for each aspect of practicality.

Table 3. Results of the practicality of application use

Practicality	Average Score	Percentage (%)	Category
Ease of use	4.40	88.00	Practical
Clarity of display	4.35	87.00	Practical
Smoothness of AR interaction	4.30	86.00	Practical
Learning effectiveness	4.45	89.00	Practical
Overall average	**4.38**	**87.50**	**Practical**

Learning Effectiveness (Inferential Analysis)

The effectiveness of the AR application was evaluated by comparing pretest and posttest scores of students' understanding of movement adaptation. As presented in **Table 4**, the results show a substantial increase from pretest (M = 68.40, SD ≈ 6.00) to posttest (M = 82.60, SD ≈ 5.80), with a mean difference of 14.20 points. A paired-sample t-test indicated that this difference was statistically significant ($p < 0.001$), with a large effect size (Cohen's $d > 0.80$), demonstrating a strong impact of the AR-based intervention on students' understanding.

Table 4. Learning effectiveness results

Measurement	Mean	SD
Pretest	68.40	6.00
Posttest	82.60	5.80
Mean Difference	14.20	—
p-value	< 0.001	—
Effect Size (Cohen's d)	> 0.80 (Large)	—

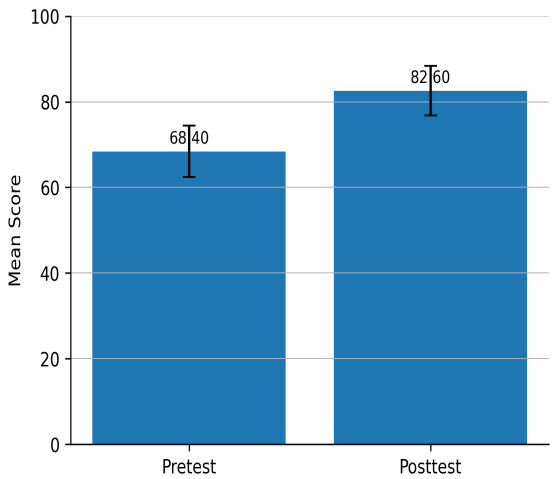

Figure 3. Pretest and Posttest Mean Scores of Students' Movement Adaptation Understanding (Mean ± SD)

As illustrated in **Figure 3**, the increase in mean scores is clearly visible, with error bars indicating the variability of the data. The visual separation between pretest and posttest further supports the statistical findings, confirming a meaningful improvement in students' understanding of disability-based movement adaptation.

4. Discussion

This study demonstrates that augmented reality (AR) can function as an effective experiential learning medium for developing adaptive competencies in inclusive physical education.

Content Validity of the AR Application

These findings are in line with previous studies emphasizing that the effectiveness of immersive learning technologies depends on the alignment between pedagogical content and technological design (Eremenko & Zalata, 2020; Nastiti et al., 2024). However, unlike prior studies that primarily focus on general instructional design, this study specifically demonstrates how such alignment can be operationalized in the context of disability-based movement adaptation, thereby extending the applicability of AR in adaptive physical education. This also supports previous findings that AR is effective when it represents learning concepts meaningfully (Dhaas, 2024; Saidin et al., 2015). Nevertheless, it should be noted that content validity based on expert judgment may be subject to evaluator bias, particularly when assessing complex pedagogical constructs such as adaptive movement strategies.

Practicality of Application Use

These findings are consistent with prior studies indicating that perceived usefulness and ease of use are key determinants of technology acceptance (Galimova et al., 2024). However, in contrast to previous research that primarily examines general user engagement, this study highlights the role of AR in reducing cognitive barriers specifically related to understanding disability-based adaptations. Similarly, AR has been shown to enhance engagement and learning effectiveness (Geana et al., 2024; Shonima & Sowmya, 2024). Despite this, the high practicality scores observed in this study may be influenced by novelty effects, suggesting that further longitudinal evaluation is required to determine sustained usability.

Effectiveness of Learning in Improving Understanding of Movement Adaptation

This finding is consistent with previous studies reporting that immersive technologies improve conceptual understanding (Izouaouen et al., 2025; Khamis et al., 2026). However, this study goes beyond prior research by demonstrating that AR not only enhances knowledge acquisition but also supports contextual and situational understanding of disability-based movement adaptation. The findings can be interpreted through experiential learning and embodied cognition perspectives (Radu & Antle, 2017). In this context, AR serves as an experiential simulation environment, enabling learners to construct knowledge through interaction rather than passive observation, which may explain the large effect size observed in this study. This is further supported by the statistically significant improvement ($p < 0.001$) and large effect size, indicating that the observed impact is not only statistically robust but also educationally meaningful.

Pedagogical Implications and Research Contributions

These findings are aligned with previous research emphasizing the importance of simulation-based learning (Levin & Flavian, 2022). However, this study extends the literature by positioning AR not

merely as a supplementary tool but as a structured experiential learning environment that supports the development of adaptive pedagogical competencies. This repositioning is particularly important in the context of inclusive physical education, where experiential exposure to diverse learner needs is often limited.

Limitations and Future Research Directions

Although the findings demonstrate strong effectiveness, several limitations should be critically acknowledged. First, the use of a one-group pretest–posttest design introduces potential threats to internal validity, including maturation and testing effects, which limit the ability to attribute the observed improvements solely to the AR intervention. As a result, the causal relationship between the intervention and learning outcomes should be interpreted with caution. Second, the relatively small and homogeneous sample size restricts the generalizability of the findings beyond the specific context of prospective physical education teachers, thereby limiting the external validity of the study. Third, this study primarily focuses on cognitive outcomes, which does not fully capture the multidimensional nature of adaptive pedagogical competence, including affective and behavioral components such as teaching self-efficacy and attitudes toward inclusion. Finally, the short-term nature of the intervention limits the understanding of the sustainability of AR-based learning outcomes over time.

Based on these limitations, future research should employ more rigorous experimental designs, such as quasi-experimental or randomized controlled trials, to strengthen causal inference. In addition, future studies should involve larger and more diverse samples and adopt multidimensional assessment frameworks that encompass cognitive, affective, and behavioral outcomes. The integration of AR with pedagogical approaches such as microteaching, experiential learning, and collaborative learning is also recommended to enhance the development of adaptive competencies. Overall, these findings highlight the potential of AR as a scalable and pedagogically meaningful approach for advancing adaptive competencies in inclusive physical education.

5. Conclusion and Recommendation

This study successfully developed an augmented reality (AR) application as a simulation medium for movement adaptation based on disability types in adaptive physical education learning at universities. The evaluation results showed that the developed application had excellent content validity, was practical to use, and was effective in improving students' understanding of disability-based movement adaptation. These findings show that AR can be a useful and practical tool for helping future physical education teachers learn how to adapt their teaching for students with disabilities. Scientifically and pedagogically, this study contributes to the development of the use of immersive technology in physical education by placing prospective teachers as the main subjects of learning. The innovation of this research resides in the amalgamation of movement adaptation simulations for diverse disabilities within a singular AR platform. While still in the pilot stage, the findings of this study present avenues for further advancement via extensive experimental research and investigation into its effects on the teaching preparedness and inclusive attitudes of prospective educators, aligning with the inclusive education objectives advocated by UNESCO.

Acknowledgement

The authors would like to thank the Directorate of Research and Community Service of Universitas Islam Riau for funding this research under contract number 735/KONTRAK/P-NK-PD/DPPM-UIR/10-2025. We also thank all participants and team members who have supported this research.

Conflict of interest

The authors declare no conflicts of interest related to this study.

References

Cena, H., & Calder, P. C. (2020). Defining a healthy diet: Evidence for the role of contemporary dietary patterns in health and disease. *Nutrients*, *12*(2), 1–15. https://doi.org/10.3390/nu12020334

Conde-Pipó, J., Mora-Fernandez, A., Martinez-Bebia, M., Gimenez-Blasi, N., Lopez-Moro, A., Latorre, J. A., Almendros-Ruiz, A., Requena, B., & Mariscal-Arcas, M. (2024). Intermittent Fasting: Does It Affect Sports Performance? A Systematic Review. *Nutrients*, *16*(1), 1–14. https://doi.org/10.3390/nu16010168

Dhaas, A. (2024). Augmented Reality in Education: A Review of Learning Outcomes and Pedagogical Implications. *American Journal of Computing and Engineering*, *7*(3), 1–18. https://doi.org/10.47672/ajce.2028

Domaszewski, P., Konieczny, M., Pakosz, P., Baczkowicz, D., & Sadowska-Krępa, E. (2020). Effect of a six-week intermittent fasting intervention program on the composition of the human body in women over 60 years of age. *International Journal of Environmental Research and Public Health*, *17*(11), 1–9. https://doi.org/10.3390/ijerph17114138

Eremenko, Y., & Zalata, O. (2020). Psychophysiological Approaches to Instructional Design for Immersive Environments. *Educational Studies Moscow*, *4*, 207–231. https://doi.org/10.17323/1814-9545-2020-4-207-231

Gabel, K., Hamm, A., Czyzewski, O., Sanchez Perez, J., Fought-Boudaia, A., Motl, R. W., & Hibbing, P. R. (2025). A Narrative Review of Intermittent Fasting With Exercise. *Journal of the Academy of Nutrition and Dietetics*, *125*(2), 153–171. https://doi.org/10.1016/j.jand.2024.05.015

Galimova, E. G., Oborsky, A. Y., Khvatova, M. A., Astakhov, D. V, Orlova, E. V, & Andryushchenko, I. S. (2024). Mapping the interconnections: A systematic review and network analysis of factors influencing teachers' technology acceptance. *Frontiers inEducation*, *9*, 1–19. https://doi.org/10.3389/feduc.2024.1436724

Garvey, W. T., & Mechanick, J. I. (2020). Proposal for a Scientifically Correct and Medically Actionable Disease Classification System (ICD) for Obesity. *Obesity*, *28*(3), 484–492. https://doi.org/10.1002/oby.22727

Geana, M. V, Cernusca, D., & Liu, P. (2024). Beyond the dawn of virtualized learning environments: A comparative study of video and augmented reality information delivery on student engagement and knowledge retention. *Journal of Computer Assisted Learning*, *40*(2), 394–409. https://doi.org/10.1111/jcal.12890

Harris, L., Hamilton, S., Azevedo, L. B., Olajide, J., De Brún, C., Waller, G., Whittaker, V., Sharp, T., Lean, M., Hankey, C., & Ells, L. (2018). Intermittent fasting interventions for treatment of overweight and obesity in adults: A systematic review and meta-analysis. *JBI Database of Systematic Reviews and Implementation Reports*, *16*(2), 507–547. https://doi.org/10.11124/JBISRIR-2016-003248

Hita, I. P. A. D. (2020). Efektivitas Metode Latihan Aerobik dan Anaerobik untuk Menurunkan Tingkat Overweight dan Obesitas. *Jurnal Penjakora*, *7*(2), 135. https://doi.org/10.23887/penjakora.v7i2.27375

Iqbal, M. Z., Mangina, E., & Campbell, A. G. (2022). Current Challenges and Future Research Directions in Augmented Reality for Education. *Multimodal Technologies and Interaction*, *6*(9), 1–29. https://doi.org/10.3390/mti6090075

Izouaouen, Z., Kharmoum, N., & Ziti, S. (2025). Education Enhanced: Impact of Immersive Technologies on Teaching and Learning Outcomes. *2025 International Conference on Circuit, Systems and Communication (ICCSC)*, 1–6. https://doi.org/10.1109/ICCSC66714.2025.11135372

Jia, E., Zhu, H., Geng, H., Liu, R., Wo, X., Zeng, Y., Ma, W., Yao, X., Zhan, Z., & Zhang, J. (2022). The effects of aerobic exercise on body composition in overweight and obese patients with

gout: A randomized, open-labeled, controlled trial. *Trials*, *23*(1), 1–11. https://doi.org/10.1186/s13063-022-06695-x

Kementrian Kesehatan RI. (2023). *Survei Kesehatan Indonesia (SKI) 2023*. Publikasi. https://www.badankebijakan.kemkes.go.id/hasil-ski-2023/

Khalafi, M., Symonds, M. E., Maleki, A. H., Sakhaei, M. H., Ehsanifar, M., & Rosenkranz, S. K. (2024). Combined versus independent effects of exercise training and intermittent fasting on body composition and cardiometabolic health in adults: A systematic review and meta-analysis. *Nutrition Journal*, *23*(1), 1–15. https://doi.org/10.1186/s12937-023-00909-x

Khamis, H., Khairudin, M., Jantan, A. H., Roslan, N. A., & Nurliyana, L. (2026). A Systematic Review of Adapting Immersive Technology in Enhancing Teaching and Learning for Students in Higher Education. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *3*(3), 28–32. https://doi.org/10.37934/araset.61.3.2832

Laksana, D. N. L. (2024). Validation Instruments for Local Culture-Based Learning Media. *Journal of Education Technology*, *8*(2), 264–274. https://doi.org/10.23887/jet.v8i 2.74446

Levin, O., & Flavian, H. (2022). Simulation-based learning in the context of peer learning from the perspective of preservice teachers: A case study. *European Journal of Teacher Education*, *45*(3), 1–8. https://doi.org/10.1080/02619768.2020.1827391

Nabila, N. N., & Sundari, S. (2024). Perancangan Augmented Reality Pengenalan Teknik Olahraga Badminton Menggunakan Metode Marker Based Tracking Berbasis Android. *Jurnal Unitek*, *17*(2), 2580–2582.

Naous, E., & Achkar, A. (2023). *Intermittent Fasting and Its Effects on Weight, Glycemia, Lipids, and Blood Pressure: A Narrative Review*. 1–18.

Nastiti, K. A., Santoso, H. B., Junus, K., Ahmad, M., & Putri, E. (2024). The Effect of Immersive Technology on Enhancing Student Learning: A Systematic Literature Review. *JITK*, *9*(2), 208–217. https://doi.org/10.33480/jitk.v9i2.4775

Nugraha, R. (2022). *Dampak Latihan dan Diet Terhadap Risiko Sindrom Metabolik*. 1–10.

Nugraha, R., Suherman, A., Ray, H. R. D., & Ma'mun, A. (2020). *The Effect of Super Set Weight Training Model and a High-Protein Diet on Body Fat Level Changes in Overweight and Obese Adult Men*. *21*(Icsshpe 2019), 192–194. https://doi.org/10.2991/ahsr.k.200214.051

Pangestu, D. A., Fitri, I., & Fauziah, F. (2020). Augmented Reality Sebagai Media Pengenalan dan Promosi Universitas Nasional. *Jurnal Teknologi Informasi*, *4*(1), 35–42. https://doi.org/10.36294/jurti.v4i1.1230

Park, H. Y., Jung, W. S., Kim, J., Hwang, H., & Lim, K. (2020). Twelve weeks of aerobic exercise at the lactate threshold improves autonomic nervous system function, body composition, and aerobic performance in women with obesity. *Journal of Obesity and Metabolic Syndrome*, *29*(1), 67–75. https://doi.org/10.7570/jomes19063

Radu, I., & Antle, A. (2017). Embodied learning mechanics and their relationship to usability of handheld augmented reality. *2017 IEEE Virtual Reality Workshop on K-12 Embodied Learning through Virtual & Augmented Reality (KELVAR)*, 1–5. https://doi.org/10.1109/KELVAR.2017.7961561

Saidin, N. F., Dayana, N., Halim, A., & Yahaya, N. (2015). A Review of Research on Augmented Reality in Education: Advantages and Applications. *International Education Studies*, *8*(13), 1–8. https://doi.org/10.5539/ies.v8n13p1

Sarma, S., Sockalingam, S., & Dash, S. (2021). Obesity as a multisystem disease: Trends in obesity rates and obesity-related complications. *Diabetes, Obesity and Metabolism*, *23*(S1), 3–16. https://doi.org/10.1111/dom.14290

Sholikhah, A. M., & Tuah, N. A. A. H. M. (2021). *Predictors of Overweight and Obesity Among Children and Adolescents in Developing Countries: A Literature Review*. 338–350. https://doi.org/10.2991/assehr.k.211223.059

Shonima, P., & Sowmya, K. S. (2024). International Journal of Research Publication and Reviews Augmented Reality: Transforming Learning Landscapes in Education. *International Journal of Research Publication and Reviews*, *5*(1), 1555–1564. https://doi.org/10.55248/gengpi.5.0124.0213

Varady, K. A., Cienfuegos, S., Ezpeleta, M., & Gabel, K. (2021). Cardiometabolic Benefits of Intermittent Fasting. *Annual Review of Nutrition*, *41*, 333–361. https://doi.org/10.1146/annurev-nutr-052020-041327

Zouhal, H., Ben Abderrahman, A., Khodamoradi, A., Saeidi, A., Jayavel, A., Hackney, A. C., Laher, I., Algotar, A. M., & Jabbour, G. (2020). Effects of physical training on anthropometrics, physical and physiological capacities in individuals with obesity: A systematic review. *Obesity Reviews*, *21*(9). https://doi.org/10.1111/obr.13039