Original Article

Android-based gymnastics learning media to improve handstand skills in junior high school students

SRI GUSTI HANDAYANI[1] , DWIPRIMA ELVANNY MYORI[2], YULIFRI[1], ANTON KOMAINI[3], DEBY TRI MARIO[1]

[1]*Department of Sport Education. Faculty of Sport Science. University Negeri Padang. Indonesia.*
[2]*Department of Electrical Engineering. Faculty of Engineering. University Negeri Padang. Indonesia.*
[3]*Department of Health & Recreation. Faculty of Sport Science. University Negeri Padang. Indonesia.*

ABSTRACT

Handstand skills are one of the materials that must be mastered by students through Physical Education (PE) learning. However, the learning media used by the teacher has not been effective in achieving this goal. Therefore, this study aims to develop Android-based gymnastics learning media to improve handstand skills in junior high school students. The design used is Research and Development (R & D) which adopts the Plomp model and pre-experimental to test its effectiveness. A total of 47 junior high school students in Indonesia participated in this study. Then, 9 experts were also involved to assess the feasibility of the product before it was implemented. The procedures in this study consisted of preliminary research, prototyping phase, and assessment phase. Product effectiveness testing includes pre-test data, use of Android-based learning media, and post-test data. The instrument used was a handstand skills test, and the duration of the treatment was ± 1 month. Validity and reliability data were analysed using the validity coefficient V from Aiken and Intraclass Correlation Coefficients (ICC), while product effectiveness used a t-test. The results showed that the average validity was 0.87 (high) and the reliability was 0.88 (very high). The results of testing the effectiveness of the product also showed that the Android-based gymnastics learning media was effective for improving handstand skills ($p < .05$), with an average post-test of 70.93 > pre-test of 63.45 and the difference is 7.48. In conclusion, students in junior high school can develop their handstand skills by using Android-based gymnastics learning media. This research is expected to be able to overcome the limitations in learning, both for PE teachers, junior high school students, and gymnastics practitioners in improving handstand skills.

Keywords: Physical education, Children, Artistic gymnastics, Handstand, Learning media, Android, Junior high school.

Cite this article as:
Handayani, S. G., Myori, D. E., Yulifri, Komaini, A., & Mario, D. T. (2023). Android-based gymnastics learning media to improve handstand skills in junior high school students. *Journal of Human Sport and Exercise, 18*(3), 690-700. https://doi.org/10.14198/jhse.2023.183.15

Corresponding author. *Department of Sport Education. Faculty of Sport Science. Universitas Negeri Padang (Padang State University), Jl. Prof. Dr. Hamka, Air Tawar Barat, Kec. Padang Utara, Kota Padang, Sumatera Barat, 25173, Indonesia.* *https://orcid.org/0000-0002-6939-8876*
E-mail: srigusti@fik.unp.ac.id
Submitted for publication March 04, 2023.
Accepted for publication March 23, 2023.
Published July 01, 2023 *(in press* April 18, 2023).
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202.

doi:10.14198/jhse.2023.183.15

INTRODUCTION

Artistic gymnastics is part of the PE curriculum at the junior high school level. This learning requires complex technical skills (Minganti et al., 2010), and involves several physical components such as strength, flexibility, and balance skills (Bradshaw et al., 2010; Sleeper et al., 2016). This includes handstand skills which are useful for acquiring other skills that are more difficult and complex (Hedbávný et al., 2013). After 3-4 years of practice, often between the age of 7-11 years, young gymnasts begin performing handstands on a flat surface like the floor (Kochanowicz et al., 2015). Balance control is needed to maintain a handstand position with a level of difficulty that continues to improve according to the next stage of the exercise (Gautier et al., 2008). In this regard, control of balance in the upright position has been the focus of various studies (Croft et al., 2008; Johannsen et al., 2007; Kibele et al., 2015; Stodolka et al., 2016).

Gymnastics skills require training and preparation based on the time available during PE learning (Coelho, 2010). Due to inadequate student preparation and experience during learning, or a lack of training for PE teachers to instruct gymnastics in a variety of settings, skills acquired are inappropriate or underdeveloped (e.g. educational, recreational and competitive) (Davis, 2018). PE teachers may not be able to identify faults in movement skills, because they do not have the necessary background in all sports (Kong, 2016), a or inexperienced in a sport (Kojima et al., 2021). The material created for the PE program, as well as the methods and modes of communication employed are additional factors (Kok et al., 2020).

It is important to note, that the PE teaching program for the secondary education level is focused on sport development and skills (Proios, 2019). This includes handstand skills. Therefore, professional teachers need to plan and implement innovative learning with the help of technology (Firdaus & Mario, 2022; Komaini et al., 2021; Warburton, 2003), and how they take advantage of various programs that are capable of producing an innovative and interactive learning media, such as Android (Doloksaribu & Triwiyono, 2020).

The success of Android is inextricably linked to open source, which offers developers a free platform on which to build their own applications (Un-Noor et al., 2017). Several previous studies have examined the various benefits of Android, such as creation of gymnastics-specific Android learning resources (Handayani et al., 2022). This study was conducted on sports education students to improve their roll ahead straddle skills. Android-based physical fitness software guide (Setiakarnawijaya et al., 2021). This study is offered on a digital platform as an application on a smartphone with the aim of serving as an educational resource for its users (athletes, sports professionals, and the general public). Mobile learning design for rhythmic gymnastics (Oktariyana et al., 2021). This study was conducted on senior high school students as an effort to improve rhythmic gymnastics during the COVID-19 period. Three-dimensional simulation for Android-based swimming training (Zhu & Kou, 2021). This study is based on virtual reality and mobile technology. Then, designing and validating Android-based wireless (Singh & Jain, 2015). This study aims for health monitoring. To our knowledge, there are very limited studies examining Android-based gymnastics learning media to improve handstand skills in junior high school students.

Therefore, this study aims to develop Android-based gymnastics learning media to improve handstand skills in junior high school students. This research is expected to be able to overcome the limitations in learning, both for PE teachers, junior high school students, and gymnastics practitioners in improving handstand skills.

MATERIALS AND METHODS

Study design

This study uses two designs, namely *R & D* which adopts the Plomp model (Plomp & Nieveen, 2013), and pre-experimental with a one group pre-test-post-test design. *R & D* design is used to design and produce products, while experimental designs are used to test their effectiveness.

Participants

A total of 47 junior high school students in Indonesia participated in this study (Table 1). This study also involved 9 experts who were competent in their fields, namely 3 gymnastics experts, 3 technology experts, and 3 language experts.

Table 1. Characteristics of participants.

Characteristics	Gender	
	Male (n = 26)	Female (n = 21)
Age	13.47 ± 0.51	13.34 ± 0.46
Weight	50.09 ± 2.29	47.91 ± 1.60
Height	150.12 ± 2.89	147.24 ± 2.82
BMI	22.23 ± 0.95	22.42 ± 1.03

Table 2. Classification of handstand skills.

Score	Classification
90 ≤ N ≤ 100	Very good
80 ≤ N ≤ 89	Good
65 ≤ N ≤ 79	Enough
30 ≤ N ≤ 64	Less
0 ≤ N ≤ 29	Very less

Procedures and instruments

The procedures in this study consisted of preliminary research, prototyping phase, and assessment phase (Plomp & Nieveen, 2013). Needs and context analysis is a stage of preliminary research (student analysis, curriculum analysis, and material analysis). The prototyping phase is the product design stage in the form of an Android-based gymnastics learning media, which contains a menu of instructions for using the media, syllabus and lesson plans, learning materials, attendance, video practice, and evaluation (assignments). Products that have been designed are assessed by experts, who independently review and evaluate the relevance of the content. Then, the assessment phase is the implementation stage to test the effectiveness of the product that has been developed. The product implementation stages consist of: (1) pre-test data, namely conducting a handstand skill test before using Android-based gymnastics learning media; (2) treatment, namely providing Android-based gymnastics learning media that has been developed. This treatment is carried out in PE learning for handstand material, with a duration of ± 1 month or 4 meetings; (3) post-test data, namely conducting a handstand skills test after using Android-based gymnastics learning media. The handstand skill test includes an initial phase, the main phase and the final phase. Handstand material includes indicators: (1) initial standing with both hands beside the ears; (2) both hands rest shoulder-width apart on the mat; (3) straightened legs; bent elbows; folded head so that the chin touches the chest; (4) leaning forward so that the body weight is on the palms of the hands; (5) roll forward by landing with your head foremost and your knees open in the shape of a "*V*" or astride; (6) pushing the hands forward between the left and right legs while trying to get up causes both hands to release the support from the mat; (7) return

to a straight, foot-to-foot stance; (8) ready position. The classification for the handstand skill test is presented in Table 2.

Statistical analysis

Testing the validity inter-ratters uses the validity coefficient V from Aiken (Aiken, 1985) and reliability using ICC (Cho, 1981) (Table 3). Then, testing the effectiveness of the product is analysed using the t-test. Data were analysed using the statistical program IBM SPSS.

Table 3. Classification for validity and reliability.

Validity		**Reliability**	
Index V	Classification	ICC	Classification
V < 0.4	Low	> 0.80	Very high
0.4 ≤ V ≤ 0.8	Enough	0.61-0.80	High
V > 0.8	High	0.41-0.60	Enough
		< 0.41	Low

Note. The alternative assessments provided are very valid/reliable (score 5), valid/reliable (score 4), enough valid/reliable (score 3), less valid/reliable (score 2), and invalid/reliable (score 1).

RESULTS

Product description

An Android-based gymnastics learning media that can be accessed on an Android device is the end result. The media includes menus, usage instructions, lesson plans, learning resources, attendance logs, practice videos, and assignments to assess handstand proficiency (Figure 1).

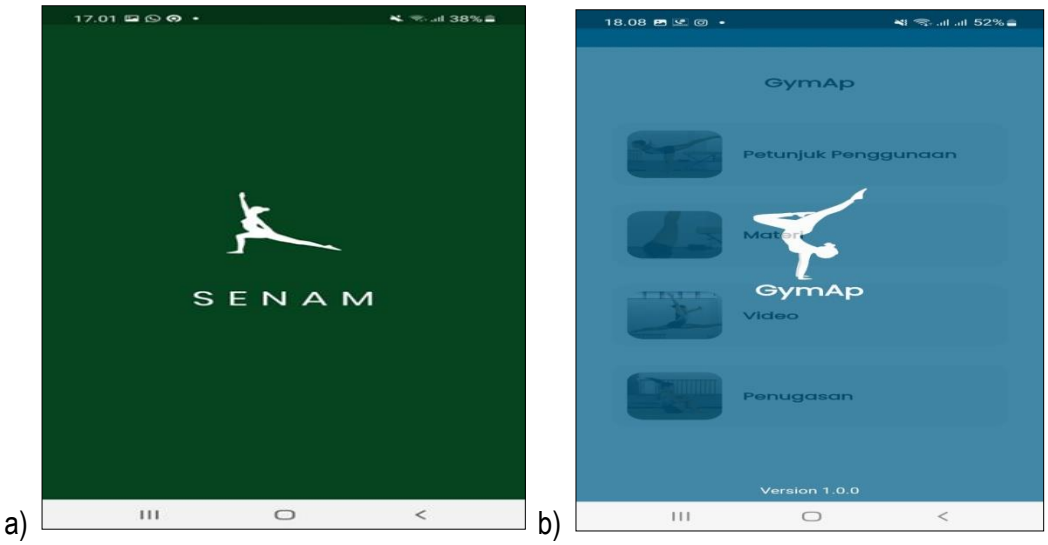

Figure 1. a) Initial appearance of the media, b) Menu on the media.

How to use media both online and offline is described in the help menu. An overview of the subjects that students will study is provided in the syllabus menu and learning implementation plan. Each meeting's material is available in pdf format on the material menu. The application's attendance menu takes the form of a link that connects straight to the absence on the instructor portal. Videos explaining how to execute

handstand moves from the starting phase to the main phase and the final phase are available on the video and practice menu. There are also videos of people performing basic handstand exercises in the video and practice menu, including videos of sit-ups for abdominal strength, push-ups for hand strength, body weight exercises on the hands for hand strength, presses for hand strength when standing up after rolling over, and body weight exercises resting on the hands. The assignment menu is made in the form of a Google form which contains instructions for assignments to be carried out by students, then uploaded by students in a format containing the student's identification number and a YouTube link.

Validity and reliability

A total of 9 experts conducted an assessment to determine its validity and reliability through written reports and discussions and came to the conclusion that the developed learning media can be implemented. The experts' responses during the revision stage are presented in Table 5. Then Table 4 is an assessment after the product has been revised. The test results show an average validity is 0.87 (high) and a reliability is 0.88 (very high). Thus, field tests can be carried out on Android-based gymnastic learning media.

Table 4. Product validity and reliability.

Experts (*N* = 9)	**Validity**	**Reliability**	**Information**	
			Validity	Reliability
Gymnastics experts (n = 3)	0.87	0.88	High	Very High
Technology experts (n = 3)	0.86	0.86	High	Very High
Language experts (n = 3)	0.89	0.90	High	Very High
ẋ	0.87	0.88	High	Very High

Table 5. Expert comments.

Experts (*N* = 9)	**Comment**
Gymnastics experts (n = 3)	Add handstand motion analysis material Add practice forms for handstand skills
Technology experts (n = 3)	The media display is designed to be more attractive The image display is clearer
Language experts (n = 3)	Use of non-standard language Clarity of letters

Implementation (product effectiveness)

Product implementation involved 47 junior high school students to prove the effectiveness of the learning media that had been developed in improving handstand skills.

Table 6. Descriptive statistics for handstand skills.

Data	**N**	**Phase**	**Min**	**Max**	***M* ± *SD***		**Classification**	$\dot{X}_2 - \dot{X}_1$
					Each phase	All phases		
Pre-test	47	Initial	49.00	75.20	63.31 ± 5.99	63.45 ± 5.28	Less	7.48
		Main	45.00	70.00	59.22 ± 5.69			
		Final	57.00	78.00	67.83 ± 5.04			
Post-test	47	Initial	55.12	83.00	69.71 ± 7.43	70.93 ± 6.65	Enough	
		Main	53.00	81.00	68.11 ± 7.28			
		Final	62.00	85.00	74.98 ± 6.18			

Note. The initial, main and final phases are a series of handstands; M ± SD is the mean and standard deviation of each phase and all phases; $\dot{X}_2 - \dot{X}_1$ *is the difference between the average pre-test and post-test data from all phases.*

The results of this descriptive analysis are presented in Table 6. Table 6 shows that there was an increase in the average handstand skill between the pre-test and post-test data, both from the initial, main and final phases. The overall average of all phases for pre-test data is 63.45 (less) and post-test is 70.93 (enough). The average difference in handstand skills between the pre-test and post-test data from each phase is presented in Figure 2.

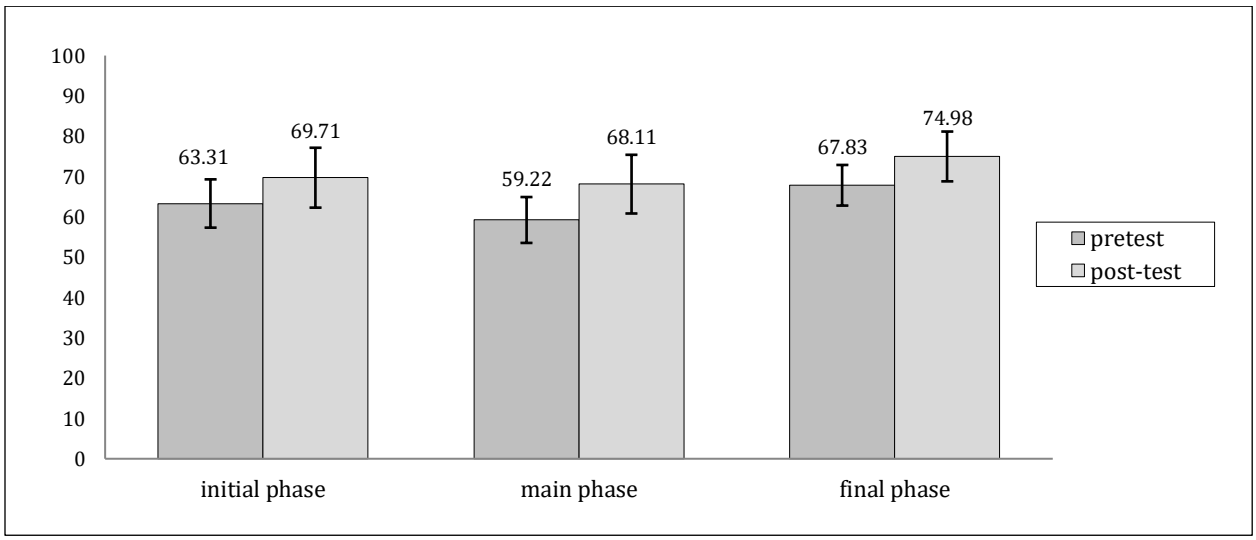

Figure 2. The average difference in handstand skills between the pre-test and post-test data from each implementation phase.

The results of the tests for normality and homogeneity also demonstrate that the data are both normally and homogeneous distributed ($p > .05$) (Table 7).

Table 7. Normality and homogeneity of data.

Normality test		**Homogeneity test**	
Data	*p*-value	Data	*p*-value
Pre-test	.745	Pre-test-post-test	.312
Post-test	.682		

Note. Data is normally distributed and homogeneous (p > .05); Shapiro-Wilk test for normality and Levene's test for homogeneity.

Then, the results of the paired samples t-test as presented in Table 8, showed that there was a significant difference between the pre-test and post-test data ($p < .05$). This means that Android-based gymnastics learning media is effectively used to improve handstand skills in junior high school students. This can be seen in Table 6, that the average pre-test-post-test data for handstand skills is 63.45 (less) < 70.93 (enough) and the difference is 7.48. Then, the value of "*r*" in Table 8 also shows that there is a significant correlation between handstand skills improvement pre-test and post-test data ($p < .05$), with a regression model Y = 5.754 + 0.885 (Figure 3).

Table 8. Paired samples t-test.

Data	**df**	**R (n = 47)**	***p*-value***	**M ± SD**	**SEM**	**t**	***p*-value (2-tailed)***
Pre-test-post-test	47	0.885	.000	7.48 ± 3.15	0.460	16.24	.000

Note. The difference is significant (p < .05).

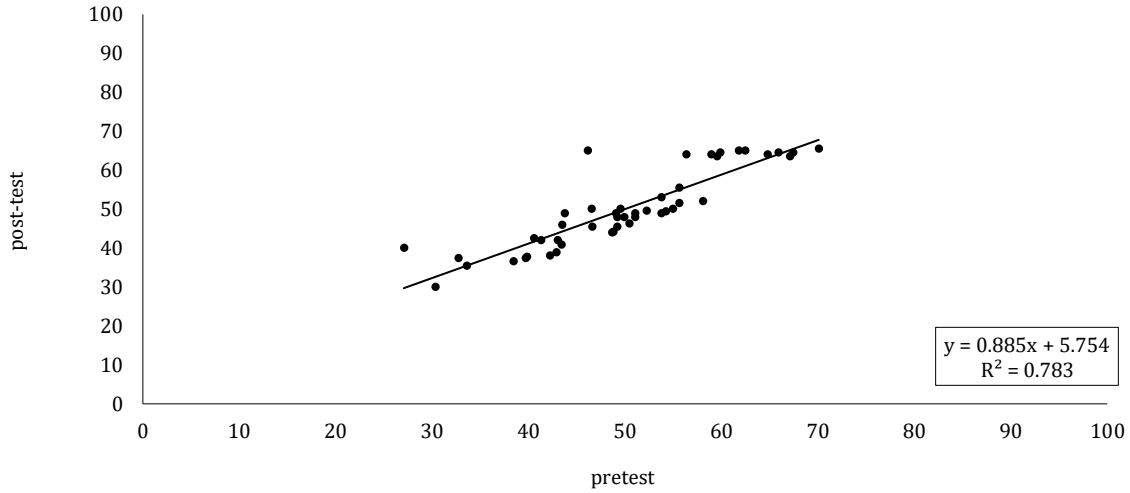

Figure 3. Linearity curve between pre-test and post-test data.

DISCUSSION

Based on the results of product development, that the average validity is 0.87 (high) and the reliability is 0.88 (very high). The results of the product implementation also showed that the Android-based gymnastics learning media was effective in improving handstand skills in junior high school students ($p < .05$). This developed Android-based learning media can be accessed anytime and anywhere without using an internet network, containing learning materials, instructions, and applications related to learning. Previous studies reported that mobile learning can be carried out during the course schedule or outside the course schedule, so that the use of Android proves to be feasible, practical, and efficient in learning (Lu'mu, 2017). Other studies also report that Android applications are very useful for helping students and teachers in the learning process (Gore et al., 2017). This can be done to overcome the limitations in learning (Açişli et al., 2011; Misbah et al., 2021).

The use of technology in the field of education can help the learning process, both for developing, processing and presenting material, so as to create a learning atmosphere that arouses student interest and learning motivation (Aremu & Efuwape, 2013). Students can use technology in learning, such as Android as a tool to help study success (Shoraevna et al., 2021), make the educational process more engaging (Burbules et al., 2020), exciting and inspiring (Gómez-Carrasco et al., 2020; Schmid & Petko, 2019), so that students participate actively in their education (Ninaus et al., 2019; Oluwajana et al., 2019). Learning using mobile is a medium that is easy to use in achieving effective learning goals (Oktariyana et al., 2021). In addition, mobile learning can increase knowledge, collaborate with others, and enhance student experiences (McQuiggan et al., 2015).

The resulting learning media has gone through the stages of validity and reliability testing before being implemented. Content validity is carried out by involving two or more ratters who are independently tasked with reviewing and evaluating the relevance of the content represented in the instrument (Wynd et al., 2003). Determination of reliability also shows the consistency of judgments (Robertson et al., 2013), where ICC is used to analyse the level of agreement among several ratters (Koo & Li, 2016; Weir, 2005). These results are consulted to make improvements until an agreement is reached for field trials.

Based on the data obtained during the development to product implementation stages, we realize that there are some limitations. The sample used for product implementation was 47 junior high school students in Indonesia, consisting of males (n = 26) and females (n = 21), so a wider sample size and diversity is needed, and comparisons between students and male and female. The experimental design used was one group pre-test-post-test design, so a comparison group was needed to test the effectiveness of the product.

CONCLUSIONS

The conclusion from the results of this study are the creation of a product in the form of Android-based gymnastics learning media to improve handstand skills in junior high school students. This is consistent with the results of the average expert validity of 0.87 (high) and reliability of 0.88 (very high). The results of testing the effectiveness of the product also showed that the Android-based gymnastics learning media was effective for improving handstand skills (p < .05), with an average post-test of 70.93 > pre-test of 63.45 and the difference is 7.48. Thus, junior high school students' handstand skills can be improved by using this learning media. The results of this study are expected to help PE teachers, junior high school students, and gymnastics practitioners improve their handstand techniques.

AUTHOR CONTRIBUTIONS

Sri Gusti Handayani: study design, data collection, statistical analysis, manuscript preparation and, funds collection. Dwiprima Elvanny Myori: study design, data collection, statistical analysis and, manuscript preparation. Yulifri: study design, data collection, statistical analysis and, manuscript preparation. Anton Komaini: study design, data collection, statistical analysis and, manuscript preparation. Deby Tri Mario: study design, data collection, statistical analysis and, manuscript preparation. Hereby, certify that all co-authors have contributed to the published work and agree to be published on JHSE.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest were reported by the authors.

REFERENCES

Açişli, S., Yalçin, S. A., & Turgut, Ü. (2011). Effects of the 5E learning model on students' academic achievements in movement and force issues. Procedia - Social and Behavioral Sciences, 15, 2459-2462. https://doi.org/10.1016/j.sbspro.2011.04.128

Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. Educational and Psychological Measurement, 45(1), 131-142. https://doi.org/10.1177/0013164485451012

Aremu, A., & Efuwape, B. M. (2013). A microsoft learning content development system (LCDS) based learning package for electrical and electronics technology-issues on acceptability and usability in Nigeria. American Journal of Educational Research, 1(2), 41-48. https://doi.org/10.12691/education-1-2-2

Bradshaw, E., Hume, P., Calton, M., & Aisbett, B. (2010). Reliability and variability of day-to-day vault training measures in artistic gymnastics. Sports Biomechanics, 9(2), 79-97. https://doi.org/10.1080/14763141.2010.488298

Burbules, N. C., Fan, G., & Repp, P. (2020). Five trends of education and technology in a sustainable future. Geography and Sustainability, 1, 93-97. https://doi.org/10.1016/j.geosus.2020.05.001

Cho, D. W. (1981). Inter-rater reliability: Intraclass correlation coefficients. Educational and Psychological Measurement, 41(1), 223-226. https://doi.org/10.1177/001316448104100127

Coelho, J. (2010). Gymnastics and movement instruction. Journal of Physical Education, Recreation & Dance, 81(1), 14-18. https://doi.org/10.1080/07303084.2010.10598409

Croft, J. L., Von Tscharner, V., & Zernicke, R. F. (2008). Movement variability and muscle activity relative to center of pressure during unipedal stance on solid and compliant surfaces. Motor Control, 12(4), 283-295. https://doi.org/10.1123/mcj.12.4.283

Davis, L. (2018). ComPETEnce in educational gymnastics: Shaping PETE students' attitudes. Journal of Physical Education, Recreation and Dance, 89(8), 41-46. https://doi.org/10.1080/07303084.2018.1503122

Doloksaribu, F. E., & Triwiyono, T. (2020). The Reconstruction Model of Science Learning based PhET-Problem Solving. International Journal on Studies in Education, 3(1), 37-47. https://doi.org/10.46328/ijonse.30

Firdaus, K., & Mario, D. T. (2022). Development of service sensor tools on table tennis net. Journal of Physical Education and Sport, 22(6), 1449-1456. https://doi.org/10.7752/jpes.2022.06182

Gautier, G., Thouvarecq, R., & Vuillerme, N. (2008). Postural control and perceptive configuration: Influence of expertise in gymnastics. Gait and Posture, 28(1), 46-51. https://doi.org/10.1016/j.gaitpost.2007.09.007

Gómez-Carrasco, C. J., Monteagudo-Fernández, J., Moreno-Vera, J. R., & Sainz-Gómez, M. (2020). Evaluation of a gamification and flipped-classroom program used in teacher training: Perception of learning and outcome. PLoS ONE, 15(7 July), 1-19. https://doi.org/10.1371/journal.pone.0236083

Gore, J., Lloyd, A., Smith, M., Bowe, J., Ellis, H., & Lubans, D. (2017). Effects of professional development on the quality of teaching: Results from a randomised controlled trial of Quality Teaching Rounds. Teaching and Teacher Education, 68, 99-113. https://doi.org/10.1016/j.tate.2017.08.007

Handayani, S. G., Syahara, S., Sin, T. H., & Komaini, A. (2022). Development of Android-based gymnastics learning media to improve the ability to roll ahead straddle students in gymnastic learning. Linguistics and Culture Review, 6, 275-290. https://doi.org/10.21744/lingcure.v6nS3.2144

Hedbávný, P., Sklenaříková, J., Hupka, D., & Kalichová, M. (2013). Balancing in handstand on the floor. Science of Gymnastics Journal, 5(3), 69-80.

Johannsen, L., Wing, A. M., & Hatzitaki, V. (2007). Effects of maintaining touch contact on predictive and reactive balance. Journal of Neurophysiology, 97(4), 2686-2695. https://doi.org/10.1152/jn.00038.2007

Kibele, A., Granacher, U., Muehlbauer, T., & Behm, D. G. (2015). Stable, unstable and metastable states of equilibrium: definitions and applications to human movement. Journal of Sports Science & Medicine, 14(4), 885-887.

Kochanowicz, A., Kochanowicz, K., Niespodzinski, B., Mieszkowski, J., & Biskup, L. (2015). The level of body balance in a handstand and the effectiveness of sports training in gymnastics. Baltic Journal of Health and Physical Activity, 7(4), 117-124. https://doi.org/10.29359/bjhpa.07.4.11

Kojima, M., Kinomura, Y., & Kuzuhara, K. (2021). Development of observational indicators for evaluating handstand posture in the mat exercise in physical education class: Validity and reliability. Journal of Physical Education and Sport, 21(3), 2087-2096. https://doi.org/10.7752/jpes.2021.s3266

Kok, M., Komen, A., van Capelleveen, L., & van der Kamp, J. (2020). The effects of self-controlled video feedback on motor learning and self-efficacy in a Physical Education setting: an exploratory study on the shot-put. Physical Education and Sport Pedagogy, 25(1), 49-66. https://doi.org/10.1080/17408989.2019.1688773

Komaini, A., Hidayat, H., Ganefri, G., Alnedral, A., Kiram, Y., Gusril, G., & Mario, D. T. (2021). Motor learning measuring tools: A design and implementation using sensor technology for preschool education. International Journal of Interactive Mobile Technologies, 15(17), 177-191. https://doi.org/10.3991/ijim.v15i17.25321

Kong, P. W. (2016). A simple and objective method for analyzing a gymnastics skill. European Journal of Physical Education and Sport, 12(2), 46-57. https://doi.org/10.13187/ejpe.2016.12.46

Koo, T. K., & Li, M. Y. (2016). A Guideline of selecting and reporting Intraclass Correlation Coefficients for reliability research. Journal of Chiropractic Medicine, 15(2), 155-163. https://doi.org/10.1016/j.jcm.2016.02.012

Lu'mu. (2017). Learning media of applications design based Android mobile smartphone. International Journal of Applied Engineering Research, 12(17), 6576-6585.

McQuiggan, S., McQuiggan, J., Sabourin, J., & Kosturko, L. (2015). Mobile learning: A handbook for developers, educators, and learners. John Wiley & Sons. https://doi.org/10.1002/9781118938942

Minganti, C., Capranica, L., Meeusen, R., Amici, S., & Piacentini, M. F. (2010). Validity of session RPE method for quantifying training load in teamgym. Journal of Strength and Conditioning Research, 24(11), 3063-3068. https://doi.org/10.1519/jsc.0b013e3181cc26b9

Misbah, M., Khairunnisa, Y., Amrita, P. D., Dewantara, D., Mahtari, S., Syahidi, K., Muhammad, N., Prahani, B. K., & Deta, U. A. (2021). The effectiveness of introduction to nuclear physics e-module as a teaching material during covid-19 pandemic. Journal of Physics: Conference Series, 1760(1), 1-6. https://doi.org/10.1088/1742-6596/1760/1/012052

Ninaus, M., Greipl, S., Kiili, K., Lindstedt, A., Huber, S., Klein, E., Karnath, H. O., & Moeller, K. (2019). Increased emotional engagement in game-based learning - A machine learning approach on facial emotion detection data. Computers and Education, 142, 1-10. https://doi.org/10.1016/j.compedu.2019.103641

Oktariyana, Asmawi, M., Sulaiman, I., Oktariyani, Sukmawati, N., Lanos, M. E. C., & Lestari, H. (2021). Design of mobile learning rhythmic gymnastics materials for high school/vocational high school levels as a distance learning media during the COVID-19 pandemic. International Journal of Human Movement and Sports Sciences, 9(3), 394-402.

Oluwajana, D., Idowu, A., Nat, M., Vanduhe, V., & Fadiya, S. (2019). The adoption of students' hedonic motivation system model to gamified learning environment. Journal of Theoretical and Applied Electronic Commerce Research, 14(3), 156-167. https://doi.org/10.4067/S0718-18762019000300109

Plomp, T., & Nieveen, N. (2013). Educational design research: An introduction. SLO.

Proios, M. (2019). Effects of practice style on a complex gymnastics skill performance of high-, medium-, and low-skilled learners. Science of Gymnastics Journal, 11(1), 77-90. https://doi.org/10.52165/sgj.11.1.77-90

Robertson, S. J., Burnett, A. F., & Cochrane, J. (2013). Tests examining skill outcomes in sport: A systematic review of measurement properties and feasibility. Sports Medicine, 44(4), 501-518. https://doi.org/10.1007/s40279-013-0131-0

Schmid, R., & Petko, D. (2019). Does the use of educational technology in personalized learning environments correlate with self-reported digital skills and beliefs of secondary-school students? Computers and Education, 136, 75-86. https://doi.org/10.1016/j.compedu.2019.03.006

Setiakarnawijaya, Y., Safadilla, E., Rahmadani, E. A., Robianto, A., & Fachrezzy, F. (2021). Android-based physical fitness software guidance. Journal of Physical Education and Sport, 21(4), 2313-2319. https://doi.org/10.7752/jpes.2021.s4295

Shoraevna, Z. Z., Eleupanovna, Z. A., Tashkenbaevna, S. N., Zulkarnayeva, Z., Anatolevna, L. L., & Nurlanbekovna, U. A. (2021). Teachers' views on the use of Information and Communication Technologies (ICT) in education environments. International Journal of Emerging Technologies in Learning, 16(3), 261-273. https://doi.org/10.3991/ijet.v16i03.18801

Singh, M., & Jain, N. (2015). Design and validation of Android based wireless integrated device for ubiquitous health monitoring. Wireless Personal Communications, 84(4), 3157-3170. https://doi.org/10.1007/s11277-015-2792-5

Sleeper, M. D., Kenyon, L. K., Elliott, J. M., & Cheng, M. S. (2016). Measuring sport-specific physical abilities in male gymnasts: the men's gymnastics functional measurement tool. International Journal of Sports Physical Therapy, 11(7), 1082-1100.

Stodolka, J., Golema, M., & Migasiewicz, J. (2016). Balance maintenance in the upright body position: Analysis of autocorrelation. Journal of Human Kinetics, 50(1), 45-52. https://doi.org/10.1515/hukin-2015-0140

Un-Noor, F., Padmanaban, S., Mihet-Popa, L., Mollah, M. N., & Hossain, E. (2017). A comprehensive study of key electric vehicle (EV) components, technologies, challenges, impacts, and future direction of development. Energies, 10(8). https://doi.org/10.3390/en10081217

Warburton, K. (2003). Deep learning and education for sustainability. International Journal of Sustainability in Higher Education, 4(1), 44-56. https://doi.org/10.1108/14676370310455332

Weir, J. P. (2005). Quantifying test-retest reliability using the Intraclass Correlation Coefficient and the Sem. Journal of Strength and Conditioning Research, 19(1), 231-240. https://doi.org/10.1519/00124278-200502000-00038

Wynd, C. A., Schmidt, B., & Schaefer, M. A. (2003). Two quantitative approaches for estimating content validity. Western Journal of Nursing Research, 25(5), 508-518. https://doi.org/10.1177/0193945903252998

Zhu, X., & Kou, F. (2021). Three-dimensional simulation of swimming training based on Android mobile system and virtual reality technology. Microprocessors and Microsystems, 82, 1-7. https://doi.org/10.1016/j.micpro.2021.103908

