



Augmented Reality Media to Improve Concepts Understanding and Biomotor Skills

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ABSTRAK

Keterampilan biomotorik siswa masih berada pada kategori rendah dan sumber belajar digital pada permainan tradisional juga masih minim. Tujuan penelitian ini yaitu menganalisis validitas, kepraktisan, menguji keefektifan, dan menganalisis respons pengguna media AR. Penelitian ini termasuk dalam jenis penelitian pengembangan. Adapun subjek penelitian ini adalah uji validitas ahli isi, ahli desain pembelajaran, dan ahli media. Uji kepraktisan melibatkan 3 orang siswa tahap perorangan dan 12 orang siswa tahap kelompok kecil. Respons pengguna melibatkan seluruh siswa kelas eksperimen dan guru pengajar. Kelas eksperimen melibatkan 32 orang siswa dan kelas kontrol terdiri atas 35 orang siswa. Metode pengumpulan data yang digunakan adalah kuesioner dan tes. Sementara, metode analisis data dilakukan dengan analisis deskriptif kualitatif, analisis deskriptif kuantitatif, dan analisis statistik inferensial. Hasil penelitian menunjukkan bahwa validitas aspek isi, media, desain pembelajaran, kepraktisan, dan respons pengguna terhadap media AR berada pada kategori sangat baik. Maka dari itu, diketahui bahwa kebaruan media AR memiliki dampak yang signifikan dalam meningkatkan pemahaman konsep dan keterampilan biomotorik setelah mengontrol pengetahuan awal siswa. Implikasi penelitian ini yaitu dapat dijadikan dasar pengembangan visualisasi 3 dimensi untuk melatih kemampuan biomotorik siswa.

ABSTRACT

Students' biomotor skills are still in the low category and digital learning resources for traditional games are still minimal. The aim of this research is to analyze validity, practicality, test effectiveness, and analyze AR media user responses. This research is included in the type of development research. The subject of this research is the validity test of content experts, learning design experts, and media experts. The practical test involved 3 students at individual level and 12 students at small group level. User responses involved all experimental class students and teaching teachers. The experimental class involved 32 students and the control class consisted of 35 students. The data collection methods used were questionnaires and tests. Meanwhile, the data analysis method was carried out using qualitative descriptive analysis, quantitative descriptive analysis and inferential statistical analysis. The research results show that the validity of aspects of content, media, learning design, practicality and user response to AR media are in the very good category. Therefore, it is known that the novelty of AR media has a significant impact in increasing understanding of concepts and biomotor skills after controlling for students' initial knowledge. The implication of this research is that it can be used as a basis for developing 3-dimensional visualization to train students' biomotor skills.

1. INTRODUCTION

Education is a crucial basis for forming superior individuals and communities. The hope is that improving the quality of human resources can be achieved through educational efforts (Kertia, 2019; Sulaksana & Wibawa, 2019; Dewi et al., 2018). Education combined with games provides a fun learning experience. One type of game is traditional games. Traditional games are folk games that develop in society and become a culture or characteristic of a country (Munir & Awiria, 2020; Hakim, 2019). Traditional games

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or often called traditional sports are a type of folk game that grows and develops in a particular community, passed down from generation to generation. This game needs to be preserved, apart from being a sports activity, it can also be an entertainment activity and a social interaction activity. It is important to preserve traditional games because they contain values. In a game there are values and characters that can be formed indirectly. Through this game, children can learn about respect, discipline, honesty, self-confidence, hard work, cooperation, sportsmanship, independence and communication (Sholikin et al., 2022; Widiastuti & Kusuma, 2021). There are various advantages and benefits of traditional games, namely, training children's creativity, developing children's social and emotional intelligence, as a medium for learning values, developing children's motor skills and biomotor abilities, beneficial for health, optimizing children's cognitive abilities, and providing joy and happiness.

Efforts to preserve traditional games through formal education have now been included in the curriculum with competencies regarding traditional games. At the junior high school level, traditional games are included in physical education, sports and health subjects. The competency content of traditional games in PJOK subjects aims to develop physical fitness and moral formation of students. This makes traditional games a "tool" for education as well as cultural preservation. Considering that these two terms have a close meaning as a process of transferring and instilling traditional and moral values. This process is a prerequisite that allows humans to be able to maintain their survival as humans. Thus, traditional games have values that need to be preserved from generation to generation through learning in formal education. The values contained in traditional games are apparently not comparable to their current existence among children. Traditional games are slowly starting to be abandoned and becoming foreign, especially among children in urban areas (Widiastuti & Kusuma, 2021; Nur & Asdana, 2020). The presence of various forms of toys and games has also shifted the existence of traditional games (Lindawati, 2019; Saputra, 2017). It cannot be denied that technological developments have caused traditional games to slowly become obsolete. Even though there is competency regarding traditional games in the school curriculum, this is not yet optimal and teachers still find several obstacles in teaching traditional games.

Some of the obstacles faced by educators or teachers in teaching traditional games are closely related to the components of the learning system. As is known, there are six components of the learning system, namely students, teachers, curriculum, competencies, learning processes, and learning materials. In the competency aspect, not many students have mastered the competencies set in the cognitive and psychomotor aspects of traditional games. Competency mastery of conceptual understanding of traditional games is still low. This can be seen from the average score for understanding students' concepts on the topic of traditional Balinese games, especially at SMP Negeri 1 Singaraja, which is 75, while the KKM set by the school is 80. Mastery of psychomotor competencies, especially biomotor skills in terms of practicing traditional games, is also still low. Not many students can practice biomotor skills in traditional games according to game procedures. The practice of biomotor skills tends to often go wrong because the concepts and rules of the game are not mastered well. If seen quantitatively, the average competency score in the practical aspect is 77, while the KKM determined for the skills aspect is 80.

The suboptimal understanding of concepts on the topic of traditional Balinese games is caused by several things. First, students have difficulty mastering competencies in terms of concepts, principles and procedures in PJOK subjects. Material concepts, especially in traditional games, tend to be abstract, such as concept definitions, attributes in the game concept, and the concept of game rules. This is supported by students' opinions through a survey conducted on 108 students of SMP Negeri 1 Singaraja. Survey results show that students have more difficulty mastering theory than practice. Students find it more difficult to understand theory, namely 86.1% compared to practice with a percentage of 13.9%. The main factor in this difficulty is that so far students have only learned from books and not many concrete media have been used to teach concepts in PJOK subjects (Alimuddin & Poddala, 2023; Schwieger & Ladwig, 2018).

These characteristics show that generation Z is very fluent with technology. However, there is not much learning content, especially on traditional game topics, in digital form. Currently the learning resources used are still in printed form. The learning media used in traditional games also do not meet the rules. Third, personalization, namely generation Z values experiences that can be customized and personal. Learning media that allows for personalization, such as adjusting the level of difficulty, tailoring content to their interests, or providing relevant feedback and can help meet the individual learning needs of generation Z. Generation Z tends to have a shorter attention span and prefers content that is concise and to the point. Therefore, learning media that is presented in a concise, focused and easy to digest format will be more effective. Limited learning media can have an impact on suboptimal understanding. The results of a survey conducted on students at SMP Negeri 1 Singaraja showed that the difficulties often experienced by students were understanding concepts at 51.4%, remembering concepts at 30.5%, and practicing at 18.1%. It is also alleged that the understanding of concepts on the topic of traditional games is not yet optimal because there

are not many digital media or content that are well designed in accordance with learning theories, pedagogical aspects and theories of digital message presentation.

Distance learning has also caused direct interaction between teachers and students to be limited (Seftiani et al., 2022; Warianie, 2020). This limited interaction can result in an incomprehensive understanding of concepts on traditional game topics by students. The media used in online learning is also not fully designed and student-centred. There are not many online learning media that can activate students. Learning media has not been designed to encourage students to be actively involved in learning. In fact, learning can be better when the media is able to actively involve students in learning (Mayer et al., 2020; Rahmawati et al., 2019). Media is not only designed to transmit information, but what is more important is that it is able to provide stimulus so that students are active. Students' abilities are still low in the aspect of biomotor skills. Sports practice requires precision, coordination, and speed. The low mastery of movements is caused by teachers placing more emphasis on demonstrations alone. Teachers still rarely provide opportunities for students to explore various concepts in a game movement. The movements demonstrated by the teacher in front of the children also have visual limitations with the large number of students. When the teacher demonstrates a game movement, it turns out that it tends to be difficult for students to understand. Students can only see the teacher's movements in a limited way so that the practice carried out by students is not optimal (Hakim & Azis, 2021; Chang et al., 2020). Based on several problems that exist in the PJOK subject, a solution is proposed in the form of developing digital media in the form of Augmented Reality. Augmented Reality (AR) is a technology that combines two-dimensional or three-dimensional virtual objects into a three-dimensional real environment and then projects these virtual objects in real time. Augmented Reality (AR) is a visualization technology that is currently being developed in the fields of gaming, entertainment and medicine. The use of AR is very interesting and makes it easier for users to do things. The Augmented Reality method also has advantages from an interactive side because it uses markers to display certain three-dimensional (3D) objects directed at the smartphone camera.

AR has advantages compared to video media. When compared to other media, AR has advantages in terms of interactivity (Sugiarni et al., 2022; Prasetyo et al., 2021). AR able to combine the virtual world with the real world. Biomotor skill steps are visualized and animated in detail so as to provide the same perception. Students can also make adjustments when viewing AR media content by zooming in or out on the visuals, rotating right and left so that movement details can be understood properly. AR media is also able to deepen students' memories because AR is able to present visuals realistically. The research results show that the combination of Augmented Reality technology with learning content can create new types of applications that are used to increase the effectiveness and attractiveness of learning for students in real life. Other research results show that AR is able to increase conceptual understanding, provide practical technology-based skills, and improve learning outcomes (Koparan et al., 2023; Chan et al., 2022; Auliya & Munasiah, 2020). Students can simulate skills through AR media. This virtual simulation provides concrete visualization as well as implementing skills in the real world. Students have control in accessing material presented through AR media. The control is with the students and they will learn the knowledge and skills of traditional games gradually according to their cognitive abilities.

Traditional game skills are presented based on movement stages starting from preparation, implementation and ending. Game movements will also be presented from the actor's perspective through AR visuals. Thus, the application of AR media to present traditional game simulations really supports students' understanding of concepts and procedures. This will have an impact on the optimal application of biomotor skills because AR is more effectively used to convey information through spatial presentation accompanied by audio. Several previous studies have revealed that AR can improve students' understanding of concepts, skills, or learning outcomes. There is no research that discusses the use of AR media to improve understanding of biomotor concepts and skills. As for the aim of this research is to analyze validity, analyze practice, test effectiveness, and analyze AR media user responses. It is hoped that the results of this research can be used as a basis for developing 3-dimensional visualization to train students' biomotor skills.

2. METHOD

This research is a type of development research. Products are developed using the ADDIE model with evaluation activities carried out at each stage. This evaluation aims to minimize errors made at each stage, including determining the feasibility of each stage. The ADDIE model is a generic model so that the AR media development process will be more carried out. The sample in this research is the class used in the quasi-experiment. The number of classes used in the quasi-experiment were two classes, namely one class using AR media and one class using print media. These two classes were taken randomly from 11 class VII

at SMP Negeri 1 Singaraja. To determine the class that gets AR media and print media, a lottery method is used. Details of the number of subjects or samples used in this research can be presented in [Table 1](#).

Table 1. Research Sample

No	Test Phase	Number of Subjects	Information
1	Expert Test	6	2 content experts 2 media experts 2 learning design experts
2	Individual Test	3	1 person of low ability 1 person of medium ability 1 person of high ability
3	Small Group Test	12	4 people of low ability 4 people of medium ability 4 people of high ability
4	Field Test	67	32 people in the experimental class 35 control class people

The data collection method in this research was carried out using questionnaires and tests. Questionnaire instruments are used to obtain data regarding needs analysis, assessments of experts, teachers and students. In an effort to ensure the validity of the questionnaire, activities were carried out to create grid tables, test the validity of the instrument content, and revise the instrument. The AR media validity test instrument grid can be presented below [Table 2](#).

Table 2. Product Validity Test Instrument Grid

No.	Stages Formative Evaluation	Aspect
1	Content/content expert test	1. Content coverage 2. The truth of the content 3. Content context
2	Test learning media experts	1. Interactivity 2. Adaptive 3. Appropriateness 4. Mode and style of interactivity 5. Interactivity quality 6. Quality of user interface 7. Sufficiency of additional tools/supporting materials 8. Stability during individual or group use
4	Test learning design experts	1. Competencies/Goals 2. Instructions for use 3. Content delivery strategy 4. Learning strategies 5. Assessment techniques
5	Individual test	1. Clarity of Material 2. Attractiveness 3. Text readability 4. Language 5. Ability to motivate 6. Technical Quality
6	Test small groups	1. Clarity of Material 2. Attractiveness 3. Text readability 4. Language 5. Ability to motivate 6. Technical Quality

(Barker & King, 1993)

Concept understanding is measured using tests, with the type of test developed being multiple choice. Before being used to measure conceptual understanding, the test must go through the test

development steps, namely, identifying subject learning outcomes, identifying basic competencies, identifying domains and indicators of learning outcome achievement, compiling test grids, determining assessment criteria, writing test items, expert test, field test, analysis of field test results, item revision, and test finalization. Meanwhile, The skills test aims to determine performance or performance in carrying out the scramble game. Scoring through this performance test uses a rating scale technique (rating scale). The performance measured is biomotoric ability. This development research uses three types of data analysis methods, namely qualitative descriptive analysis, quantitative descriptive analysis, and inferential statistical analysis. Data on student understanding of concepts and skills will be analyzed using Multivariate Analysis of Covariance or Mancova test statistics. The use of Mancova statistics is because in this research there are covariables in the form of prior knowledge which are controlled for the purpose of reducing error variance and reducing and eliminating the influence of experimental factors that cannot be controlled.

3. RESULT AND DISCUSSION

Result

The design process for augmented reality media is carried out based on the ADDIE model. This research has gone through product design. The design has been carried out through a series of stages starting from analysis, design, development, implementation and evaluation. This research also always carries out revisions at every stage of its development. Revisions are intended to reduce errors that occur at each stage, including assessing the adequacy of each stage. The product display resulting from the development process can be presented on [Figure 1](#).



Figure 1. Display of Products Resulting from the Development Process

The validity of the learning media that has been created, namely augmented reality, is studied from several aspects. The studies carried out are from the aspects of learning content, design validity and media validity. The assessment of the validity of media content was carried out by two experts who were proven to have mastered media topics about traditional Balinese games. The results of content, design and media validity testing are presented in [Table 3](#).

Table 3. Media Validity Testing by Experts

Aspect	Expert 1	Expert 2	Average	Category
Learning Content	100	100	100	Very good
Learning design	92.5	90	91.25	Very good
Instructional Media	92.85	89.28	91.07	Very good

Augmented reality (AR) media, which has been validated by experts, is then tested on students. The purpose of testing with students is because students act as end users, so this trial is carried out to ensure the suitability of AR media with students' characteristics. The results of student trials in individual and small group tests are presented in [Table 4](#).

Table 4. AR Media Practicality Test by Users

Stage	Respondent	Score	Average	Category
Individual Test	X1	100	95.83	Very good
	X2	92.5		
	X3	95		

Stage	Respondent	Score	Average	Category
Small Group Test	X1	100	95.00	Very good
	X2	100		
	X3	100		
	X5	95		
	X6	97.5		
	X7	87.5		
	X8	97.5		
	X9	92.5		
	X10	95		
	X11	90		
	X12	87.5		

In this research, the hypothesis tested is an alternative hypothesis as a hypothesis directed at theoretical studies. The alternative hypothesis is that there is a difference in understanding of concepts and biomotor skills between students who take part in learning using AR media and students who take part in learning using print media after students' prior knowledge is controlled. The description of the variable data for understanding concepts and biomotor skills can be presented in Table 5.

Table 5. Data Description on Concept Understanding and Biomotor Skills Variables

Dependent Variable	Media	Mean	Std. Deviation	N
Understanding	AR media	83.06	7.435	32
	Print media	74.2	9.56	35
	Total	78.43	9.644	67
Biomotor	AR media	85	7.396	32
	Print media	67.77	9.878	35
	Total	76	12.294	67

The table above shows the results of data descriptions on the variables of understanding concepts and biomotor skills. The average understanding of concepts in the experimental class was 83.063 and the control class was 74.2. The average biomotor skills in the experimental class was 85 while in the control class it was 67.77. To determine the effect of the independent variable on the dependent variable, the multivariate test presented in Table 6.

Table 6. Multivariate Test Results

Effect		Value	F	Hypothesis df	df error	Sig.
Intercept	Pillai's Trace	0.819983	143.48	2	63	0.000
	Wilks' Lambda	0.180017	143.48	2	63	0.000
	Hotelling's Trace	4.555031	143.48	2	63	0.000
	Roy's Largest Root	4.555031	143.48	2	63	0.000
Media	Pillai's Trace	0.451914	25.97	2	63	0.000
	Wilks' Lambda	0.548086	25.97	2	63	0.000
	Hotelling's Trace	0.82453	25.97	2	63	0.000
	Roy's Largest Root	0.82453	25.97	2	63	0.000
Covariables	Pillai's Trace	0.104363	3.67	2	63	0.031
	Wilks' Lambda	0.895637	3.67	2	63	0.031
	Hotelling's Trace	0.116524	3.67	2	63	0.031
	Roy's Largest Root	0.116524	3.67	2	63	0.031

Based on the data in the table above, especially in the "Media" column, it shows that the four tests using Pillai's Trace, Wilks' Lambda, Hotelling's Trace, Roy's Largest Root each obtained sig. values, namely 0.000, 0.000, 0.000, 0.000 and all of them were less than 0.05. Thus, there is a significant influence between the type of learning media on understanding concepts and biomotor skills simultaneously after controlling for initial knowledge. Next, the media impact on the dependent variable was tested separately. Based on the tests carried out, the concept understanding variable obtained a sig. value 0.003. This value is less than 0.05, so it can be concluded that there is a significant difference in the influence of the type of learning media on concept understanding after controlling for students' prior knowledge. For the biomotor skills variable, the

sig value is obtained. 0.000 is a value less than 0.05, so it can be concluded that there is a significant difference between the influence of the type of learning media on biomotor skills after controlling for initial knowledge. Next, to find out what type of media has an influence, further tests are carried out. Before carrying out further tests, a homogeneity test is first carried out using the Levene test to determine the type of further test to be used. The results of the homogeneity test, namely the Levene test, show that the concept understanding variable obtained sig. 0.308. Meanwhile, biomotor skills obtained a sig of 0.144. Both variables obtained sig > 0.05. This means that all dependent variables have the same variance. Because the results were homogeneous, a post hoc test was carried out using the Benferroni test, the results of which are presented in Table 7.

Table 7. Paired Test Results

Dependent Variable	(i) Media	(j) Media	Mean Difference (IJ)	Std. Error	Sig. (a)	95% Confidence Interval for Difference(a)	
						Lower Bound	Upper Bound
Concept	AR media	Print media	6.698	2.189	0.003	2.326	11.071
Understanding	Print media	AR media	-6.698	2.189	0.003	-11.071	-2.326
Biomotor	AR media	Print media	16.110	2.316	0.000	11.484	20.736
	Print media	AR media	-16.110	2.316	0.000	-20.736	-11.484

In the concept understanding variable, the comparison between AR media and print media obtained a sig of 0.003 which is less than 0.05. This means that there is a significant difference in conceptual understanding between learning using AR media and using print media. To find out which media is more effective, you can look at Mean Difference (IJ) of 6.698, which means that students who learn using AR media have a higher average understanding of concepts than students who learn using print media. In the biomotor skills variable, the comparison between AR media and print media obtained sig. 0.000 which is less than 0.05. This means that there is a significant difference between the biomotor skills of students learning using AR media and using print media. To find out which media is more effective in improving biomotor skills, you can look at Mean Difference (IJ) (AR Media-Print Media) of 16,111. Thus, students who learn using AR media have higher biomotor skills than students who learn using print media.

Discussion

AR media has a significant impact on understanding concepts. Three-dimensional simulations presented in AR media can make it easier for students to understand abstract concepts. Concepts can be thought of as ideas, objects or events that help a person understand the world around him. Concepts in traditional Balinese game material generally have an abstractness dimension and a structural dimension. The abstractness dimension concerns the names of movements that need to be visualized so that students have a proper understanding, while the structural dimension is that a movement concept has several parts and several parts of the movement also have derivatives. Regarding the abstractness dimension of the concept in traditional games, it is visualized with picture examples. These examples are presented in the form of still images and moving images. Providing examples and non-examples turns out to be very helpful in making it easier for students to understand the concept. For example, the concept of direct movement is exemplified by visual movement and visual non-movement (not a concept). In this way, it will speed up students' understanding of the concept rather than the teacher explaining it at length. The results of this research are in line with research which shows that example and non-example methods can improve student learning outcomes (Amrianto & Lufri, 2019; Poko, 2017).

AR media is able to clarify abstract concepts into more concrete ones in the form of three-dimensional animation. Animation presentations are able to influence understanding of concepts, namely, firstly, they are able to visualize abstract concepts, namely allowing abstract concepts to be depicted in concrete visual ways. This is in line with research which states that pStudent understanding can increase when content is equipped with animation (Aysolmaz & Reijers, 2021; Rahmadani et al., 2018). Second, understanding the concept of using motion and effects, namely animation is able to present movements in an orderly manner according to what is desired by highlighting important aspects of a concept. Third, the interactivity of AR media is able to provide students with the opportunity to interact directly with the media via smartphone. Fourth, animated displays on AR media have appeal and are able to motivate through visuals. This is in line with other research which shows that animation can increase learning motivation (Kul & Berbe, 2022; Ahmad et al., 2021).

AR media is able to have a significant influence on understanding concepts because it is related to the advantages of AR media, namely, firstly presenting realistic visualizations that allow abstract concepts to be depicted in a physical environment that resembles reality. AR can be an effective medium to help

students understand and apply concepts better (Koparan et al., 2023; Aripin & Suryaningsih, 2019). Second, it can be applied according to the context of the material. Third, encouraging student involvement, namely AR media can trigger student involvement because it is interesting and interactive. Students can explore concepts in AR media with fun. In the AR environment, students are given the freedom to be active with the content in the learning process so that they will be more motivated and able to apply the knowledge they have acquired in a real world environment (Silva et al., 2023; Hilda & Lubis 2021). AR technology allows students to interact with content visually and interactively which has an impact on students' understanding of concepts (Hariyono, 2023; Kul & Berbe, 2022). Fourth, AR media encourages collaboration and social engagement. Students can have social interactions with friends in class. Every detail of the game movement can be regulated by students themselves. The angle of presentation of the 3-dimensional simulation that you want to display can be adjusted according to the needs of each student. At this level, AR presented in a multimedia learning environment provides a high level of interactivity because it gives the user full control over their learning experience.

Such interactive systems can facilitate deep learning by actively involving students in the learning process. The research results show that interactive design can improve the learning outcomes achieved (Chang et al., 2021; AR Hakim & Windayana, 2016). Findings and several research results indicate that interactive design in AR media is able to encourage students to actively engage with the media. Students can build knowledge from their interactions with the media so that it has a positive impact on their learning outcomes. The use of AR media in traditional Balinese game topics also improves students' biomotor skills compared to students who learn through print media. AR media is able to present visuals in real time about correct body movements, correct positions and correct techniques. Students can know in advance the correct movements or the correct flow of the game before they practice. In the context of PE subjects, AR can be used to provide visual guidance and help students learn physical movements better. For example, students can see the direction of movement that indicates the correct movement when playing a game. If it is related to visualization theory. AR media is able to visualize movements so that students can experience mental processes where students can imagine or form mental images about game movements. Visualization theory states that the use of interactive visual representations through computer technology to present abstract data thus strengthens cognition. Based on the theory Neuromuscular visualization can activate the same neural pathways in the brain as physical movements. When students imagine making movements through the AR media they receive, nerve impulses flow through the same pathways that will be activated when the movement is carried out physically.

With repeated observations, these neural pathways can be strengthened so as to improve students' biomotor skills. Movements visualized using computer technology helps students imagine themselves playing traditional games without doing it in a real environment. The research results also show that visualization strategies are able to provide better perception to students (Sriyanto et al., 2019; Banerjee et al., 2015). Sweet visualization has been shown to be better for depicting motor skills. Thus, research findings, theoretical support and relevant research results show that material visualization using AR technology is the right way to improve biomotor skills.

Media AR can be used to learn biomotor skills in real-time during student interactions with virtual environments. Virtual environments can provide insight into motor performance in traditional games, such as body movement, speed, or strength. AR technology can provide significant benefits to motor skills (Dharmawan & Setyaningsih, 2022; Lee et al., 2022). AR media provides multisensory interactions involving interactions between visual, auditory and kinesthetic. The interactions students have with virtual objects, hear relevant sounds or instructions, and experience touch or movement sensations via the smartphone device. This multisensory interaction provides a more immersive and realistic experience. AR media visuals are more realistic, allowing abstract objects to be presented more realistically. Game steps, and there are animations that help students to understand and imitate the correct movements. AR media provides benefits in improving students' skills in sports (İmamoglu et al., 2022; Sari et al., 2020). Providing this feedback really helps users identify mistakes in practicing biomotor skills more quickly. For example, visual feedback shows the correct steps in executing a movement. This helps the user in understanding and imitating the desired movement better. The virtual environment in AR media facilitates individual students to gain virtual practical experience in a game environment. AR media presents game situations that are realistically replicated. Students can imitate and hone the movements displayed in AR media. Students can interact with virtual objects, thereby helping to improve students' practical abilities (Harefa et al., 2023; Burström et al., 2019). The practice carried out by students can be minimally risky because it allows students to practice in a safe and controlled situation.

These small, repetitive exercises help strengthen and build the "motor memory" necessary to improve biomotor skills. Students gain initial knowledge about the movements of the game. Based on the results of observations, it turns out that it can increase students' self-confidence. The experience gained

through AR media helps increase students' self-confidence to apply the game in real life. AR media is able to provide realistic visuals and reduce students' anxiety. This can be seen when experimental class students can practice the game well and enthusiastically. Through AR media, students can better understand concepts and can learn repeatedly to support more optimal mastery of biomotor skills. The novelty of AR media can have a significant impact in improving understanding of biomotor concepts and skills. The implication of this research is that AR technology can be the basis for developing three-dimensional visualization that can be used to train students' motor skills. Meanwhile, the limitation of this research is that random selection of classes resulted in differences in initial characteristics between groups using AR media and those using print media. Future research can perform better subject selection to reduce research bias.

4. CONCLUSION

The validity of content, media, learning design, practicality, and response aspects of Augmented Reality (AR) technology are in a very positive category. Thus, it appears that the use of AR technology has a significant impact on improving students' conceptual understanding and motor skills after controlling for their initial knowledge. Thus, in the future, similar learning media can be developed to support the learning process.

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6. REFERENCES

- Ahmad, N. J., Yakob, N., Bunyamin, M. A. H., Winarno, N., & Akmal, W. H. (2021). The Effect of Interactive Computer Animation and Simulation on Students' Achievement and Motivation in Learning Electrochemistry. *Jurnal Pendidikan IPA Indonesia*, 10(3), 311-324. <https://doi.org/10.15294/JPII.V10I3.26013>.
- Alimuddin, M., & Poddala, P. (2023). Prospek Digital Marketing Untuk Generasi Muda Dalam Berwirausaha. *Journal of Career Development*, 1(1). Retrieved from <http://download.garuda.kemdikbud.go.id/article.php?article=3518509&val=30815&>.
- Amrianto, A., & Lufri, L. (2019). Effect of Example Non Example Method Implementation in Scientific Approach and Discovery Learning Model on VII Grade Students' Psychomotor Competence in Learning Natural. *International Journal of Progressive Sciences and Technologies (IJPSAT)*, 1387(1), 012049. <https://doi.org/10.1088/1742-6596/1387/1/012049>.
- Aripin, I., & Suryaningsih, Y. (2019). Pengembangan Media Pembelajaran Biologi Menggunakan Teknologi Augmented Reality (AR) Berbasis Android pada Konsep Sistem Saraf. *Sainsmat: Jurnal Ilmiah Ilmu Pengetahuan Alam*, 8(2), 47. Retrieved from <http://download.garuda.kemdikbud.go.id/article.php?article=1534691&val=4331>.
- Auliya, R. N., & Munasiah, M. (2020). Augmented Reality Affects Students' Attitude and Conceptual Understanding in Learning 3D Geometry. *JPI (Jurnal Pendidikan Indonesia)*, 9(2), 203. <https://doi.org/10.23887/jpi-undiksha.v9i2.17480>.
- Aysolmaz, B., & Reijers, H. A. (2021). Animation as a Dynamic Visualization Technique for Improving Process Model Comprehension. *Information and Management*, 58(5), 103478. <https://doi.org/10.1016/j.im.2021.103478>.
- Banerjee, G., Murthy, S., & Iyer, S. (2015). Effect of Active Learning Using Program Visualization in Technology-Constrained College Classrooms. *Research and Practice in Technology Enhanced Learning*, 10(1), 1-25. <https://doi.org/10.1186/S41039-015-0014-0/FIGURES/6>.
- Barker, P., & King, T. (1993). Evaluating interactive multimedia courseware—A methodology. *Computer and Education*, (4), 307-319. [https://doi.org/10.1016/0360-1315\(93\)90034-G](https://doi.org/10.1016/0360-1315(93)90034-G).
- Burström, G. M., Nachabe, R. P., Persson, O. M., Edström, Erik MD, P., Terander, E., & Adrian MD, P. (2019). Augmented and Virtual Reality Instrument Tracking for Minimally Invasive Spine Surgery: A Feasibility and Accuracy Study. *Spine*, 44(15), 1097-1104. <https://doi.org/10.1097/BRS.0000000000003006>.

- Chan, V. S., Haron, H. N. H., Isham, M. I. B. M., & Mohamed, F. Bin. (2022). VR and AR Virtual Welding for Psychomotor Skills: a Systematic Review. *Multimedia Tools and Applications*, 81(9), 12459–12493. <https://doi.org/10.1007/s11042-022-12293-5>.
- Chang, K.-E., Zhang, J., Huang, Y.-S., Liu, T.-C., & Sung, Y.-T. (2020). Applying Augmented Reality in Physical Education on Motor Skills Learning. *Interactive Learning Environments*, 28(6), 685–697. <https://doi.org/10.1080/10494820.2019.1636073>.
- Chang, T.-S., Teng, Y.-K., Chien, S.-Y., & Tzeng, Y.-L. (2021). Use of an interactive multimedia e-book to improve nursing students' sexual harassment prevention knowledge, prevention strategies, coping behavior, and learning motivation: A randomized controlled study. *Nurse Education Today*, 105, 104883. <https://doi.org/10.1016/j.nedt.2021.104883>.
- Dewi, N. P. Y. K., Wiyasa, K. N., & Ardana, I. K. (2018). Pengaruh Model Pembelajaran Snowball Throwing Berbantuan Media lingkungan Terhadap Kompetensi Pengetahuan IPA. *Jurnal Pedagogi Dan Pembelajaran*, 1(1), 1–8. <https://doi.org/10.23887/jp2.v1i1.19322>.
- Dharmawan, J., & Setyaningsih, E. R. (2022). Pengaruh Penggunaan Teknologi Augmented Reality Live Texturing Pada Pembelajaran Mewarnai Anak Usia Dini Di Paud Holistik Integratif El-Fath Sumenep. *Alpen: Jurnal Pendidikan Dasar*, 5(2), 69–86. Retrieved from https://lppm.istts.ac.id/files/publication/1/kC7hvtwYodikGy23c_cKzeRAn3ooCOOp.pdf.
- Hakim, A. A. (2019). Survei Perkembangan Olahraga Tradisional Di Kabupaten Tuban. *Jurnal Kesehatan Olahraga*, 8(1), 33–38. Retrieved from <https://ejournal.unesa.ac.id/index.php/jurnal-kesehatan-olahraga/article/view/31051>.
- Hakim, A. R., & Windayana, H. (2016). Pengaruh Penggunaan Multimedia Interaktif Dalam Pembelajaran Matematika Untuk Meningkatkan Hasil Belajar Siswa. *EduHumaniora/ Jurnal Pendidikan Dasar Kampus Cibiru*, 4(2). <https://doi.org/10.17509/eh.v4i2.2827>.
- Hakim, M. F. Al, & Azis, A. (2021). Peran Guru dan Orang Tua Dalam Pembelajaran Daring Pada Masa Pandemi Covid-19. *Riwayat: Educational Journal of History and Humanities*, 4(1), 16–25. <https://doi.org/10.24815/jr.v4i1.19677>.
- Harefa, R. T. H., Lase, W. N., Telaumbanua, R., & Bawamenewi, A. (2023). Pengembangan Media Augmented Reality untuk Meningkatkan Kemampuan Menulis Teks Deskripsi Siswa SMP. *Journal on Education*, 6(1), 3241–3247. <https://doi.org/10.31004/joe.v6i1.3379>.
- Hariyono, H. (2023). Penggunaan Teknologi Augmented Reality dalam Pembelajaran Ekonomi: Inovasi untuk Meningkatkan Keterlibatan dan Pemahaman Siswa. *JiIP - Jurnal Ilmiah Ilmu Pendidikan*, 6(11), 9040–9050. <https://doi.org/10.54371/jiip.v6i11.2894>.
- HILDA, L., & LUBIS, R. (2021). *APMol: Media Teknologi Geometri Molekul Berbasis Augmented Reality dan Jmol*. Samudra Biru.
- İmamoğlu, M., Erbaş, Ç., & Dikmen, C. H. (2022). Trend Analysis of Augmented Reality Studies in Sports Science. *Kastamonu Education Journal*, 30(3), 502–511. <https://doi.org/10.24106/kefdergi>.
- Kertia, N. (2019). Penerapan Model Pembelajaran Kooperatif Tipe Role Playing untuk Meningkatkan Hasil Belajar Siswa Kelas X AP1 Pada Pelajaran PPKn. *Jurnal Pedagogi Dan Pembelajaran*, 2(1), 25–32. <https://doi.org/10.23887/jp2.v2i1.17604>.
- Koparan, T., Dinar, H., Koparan, E. T., & Haldan, Z. S. (2023). Integrating augmented reality into mathematics teaching and learning and examining its effectiveness. *Thinking Skills and Creativity*, 101245. <https://doi.org/10.1016/J.TSC.2023.101245>.
- Kul, H. S., & Berbe, A. (2022). The Effects of Augmented Reality in a 7 th -Grade Science Lesson on Students ' Academic Achievement and Motivation. *Journal of Science Learning*, 5(2), 193–203. <https://doi.org/10.17509/jsl.v5i2.42952>.
- Lee, Y.-F., Altschuld, J. W., Chiang, F.-S., Yue, C.-S. J., Sung, H.-T., & Chang, C.-H. (2022). Effects of Augmented Feedback with Error Self-estimates on Vocational High School Students' Motor Skill Learning. *Vocations and Learning*, 15(1), 1–20. <https://doi.org/10.1007/s12186-021-09273-5>.
- Lindawati, Y. I. (2019). Faktor-Faktor Penyebab Eksistensi Permainan Tradisional di Desa Nyangkringan. *Hermeneutika : Jurnal Hermeneutika*, 5(1), 13. <https://doi.org/10.30870/hermeneutika.v5i1.7381>.
- Mayer, R. E., Fiorella, L., & Andrew Stull. (2020). Five ways to increase the effectiveness of instructional video. *Educational Technology Research and Development*, 68(3), 837–852. <https://doi.org/10.1007/s11423-020-09749-6>.
- Munir, Z. A., & Awiria, A. (2020). Implementasi Pendidikan Nilai Melalui Permainan Tradisional Anak Suku Sasak di MI NW Loang Sawak Lombok Tengah. *Taman Cendekia: Jurnal Pendidikan Ke-SD-An*, 4(1), 397–403. <https://doi.org/10.30738/tc.v4i1.5764>.
- Nur, H., & Asdana, M. F. (2020). Pergeseran Permainan Tradisional Di Kota Makassar. *Phinisi Integration Review*, 3(1), 17–29. Retrieved from <http://download.garuda.kemdikbud.go.id/article.php?article=1620313&val=11114&title=>

- Poko, F. (2017). Penerapan Model Pembelajaran Example Non Examples Untuk Meningkatkan Hasil Belajar IPS. *Jurnal Penelitian Dan Pengembangan Pendidikan*, 1(1). Retrieved from <https://ejournal.undiksha.ac.id/index.php/JJL/article/view/12615>.
- Prasetyo, T. F., Bastian, A., & Sujadi, H. (2021). Optimalisasi Penerapan Teknologi Virtual Reality Tour Kampus Universitas Majalengka Menggunakan Metode multimedia Development Cycle. *INFOTECH Journal*, 7(2), 15–28. <https://doi.org/10.31949/infotech.v7i2.1313>.
- Rahmadani, H., Roza, Y., & Murni, A. (2018). Analisis Kebutuhan Bahan Ajar Matematika Berbasis Teknologi Informasi di SMA IT Albayyinah Pekanbaru. *JURING (Journal for Research in Mathematics Learning)*, 1(1), 91–98. <https://doi.org/10.24014/juring.v1i1.5230>.
- Rahmawati, N. S., Bungsu, T. K., Islamiah, I. D., & Setiawan, W. (2019). Analisis Minat Belajar Siswa Ma Al-Mubarak Melalui Pendekatan Saintifik Berbantuan Aplikasi Geogebra Pada Materi Statistika Dasar. *Journal on Education*, 1(3), 385–295. <https://doi.org/10.31004/joe.v1i3.180>.
- Saputra, S. Y. (2017). Permainan Tradisional VS Permainan Modern Dalam Penanaman Nilai Karakter di Sekolah Dasar. *ELSE (Elementary School Education Journal): Jurnal Pendidikan Dan Pembelajaran Sekolah Dasar*, 1(1). <https://doi.org/10.30651/else.v1i1.873>.
- Sari, A. K., Ningsih, P. R., Ramansyah, W., Kurniawati, A., Siradjuddin, I. A., & Sophan, M. K. (2020). Pengembangan Kompetensi Guru SMKN 1 Labang Bangkalan Melalui Pembuatan Media Pembelajaran Augmented Reality Dengan Metaverse. *Jurnal Pengabdian Pada Masyarakat*, 4(1), 52–59. <https://doi.org/10.20956/pa.v4i1.7620>.
- Schwieger, D., & Ladwig, C. (2018). Reaching and Retaining the Next Generation: Adapting to the Expectations of Gen Z in the Classroom. *Information Systems Education Journal*, 16(3), 45–54. Retrieved from <https://isedj.org/2018-16/n3/ISEDJv16n3p45.html>.
- Seftiani, D. S., Uswatun, D. A., & Amalia, A. R. (2022). Analisis Perbandingan Motivasi Belajar Siswa pada Pembelajaran Jarak Jauh dan Pembelajaran Tatap Muka Terbatas. *Basic*, 6(4), 6412–6418. <https://doi.org/10.31004/basicedu.v6i4.3223>.
- Sholikin, M., Fajrie, N., & Ismaya, E. A. (2022). Nilai Karakter Anak Pada Permainan Tradisional Gobak Sodor dan Egrang. *Jurnal Educatio FKIP UNMA*, 8(3), 1111–1121. <https://doi.org/10.31949/educatio.v8i3.3035>.
- Silva, M., Bermúdez, K., & Caro, K. (2023). Effect of an augmented reality app on academic achievement, motivation, and technology acceptance of university students of a chemistry course. *Computers & Education*, 2(4), 1–9. <https://doi.org/10.1016/j.cexr.2023.100022>.
- Sriyanto, S., Febrianta, Y., & Yuwono, P. H. (2019). Strategi Berpikir Visual Bagi Peserta Didik Gangguan Kecemasan Sosial Untuk Mengembangkan Keterampilan Sosial. *JSSH (Jurnal Sains Sosial Dan Humaniora)*, 3(1), 65–78. <https://doi.org/http://dx.doi.org/10.30595/jssh.v3i1.3064>.
- Sugiarni, R., Inayah, S., Herman, T., Juandi, D., Pahmi, S., Supriyadi, E., ... Mahmudi. (2022). Sosialisasi Penggunaan teknologi Virtual Reality dan Augmented Reality Dalam Pembelajaran Untuk Menyongsong Metaverse. *Jurnal Abdi Nusa*, 2(3), 134–140. <https://doi.org/10.52005/abdinusa.v2i3.99>.
- Sulaksana, Y. T., & Wibawa, I. G. M. I. M. C. (2019). Pengaruh Model Pembelajaran SAVI(Somatic Auditory Visualization Intellectually) Berbantuan LKS terhadap Hasil Belajar IPA. *Jurnal Pedagogi Dan Pembelajaran*, 1(3), 180–188. <https://doi.org/10.23887/jp2.v1i3.19346>.
- Warianie, L. (2020). Peranan Penting Guru, Orang Tua, dan Siswa Dalam Menghadapi Pembelajaran Jarak Jauh di Masa Pandemi Covid 19. *ENGGANG: Jurnal Pendidikan, Bahasa, Sastra, Seni, Dan Budaya*, 1(1), 16–29. <https://doi.org/10.37304/enggang.v1i1.2350>.
- Widiastuti, N. M. D., & Kusuma, P. S. D. (2021). Kajian Permainan Tradisional Bali Untuk Membantu Pembentukan Karakter Dan Keterampilan Sosial Anak. *Segara Widya : Jurnal Penelitian Seni*, 9(2), 98–105. <https://doi.org/10.31091/sw.v9i2.1740>.