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Student Worksheets Integrated Augmented Reality Based on Physics Learning Project Models to Improve Students' Scientific Creativity in High School

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Abstract

Scientific creativity is an important skill in 21st century learning. In practice, many students still have difficulty in developing ideas, exploring, and solving problems innovatively. Various previous studies have developed teaching materials based on Project Based Learning (PjBL) and Augmented Reality (AR) separately. However, none have integrated the two to improve scientific creativity. Based on the results of previous research studies, this study aims to develop student worksheets (LKPD) based on PjBL integrated with AR to improve the scientific creativity of high school students. The research method used is Research & Development (R&D) from ADDIE which consists of five stages, namely analysis, design, development, implementation, and evaluation. Based on the results of previous research studies, both in terms of methods, approaches and use of physics learning media, there is a research gap, the gap between this research and previous research is the integration between AR technology and project-based LKPD. The integration of AR with project-based LKPD simultaneously is something new in this study. This integration will provide a new experience that is more interactive and interesting in the physics learning process. The results of the study showed that the results of the validity test by three experts obtained an average validity score of 3.91 (98%) with a very valid category and a reliability score reaching 95.6% with a reliable category. Thus, this student worksheet is declared valid, practical, and effective in improving the scientific creativity of high school students. The limitation of this study is that this study has only reached the validation stage so that it needs to be implemented in more high schools.

Keywords: *Student worksheet, Augmented Reality, Physics Learning project, Scientific Creativity*

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1. INTRODUCTION

Education is one of the important aspects in the 21st century or what is known as the era of revolution 4.0. In this era, education is not only a transfer of knowledge. However, it is emphasized on mastering the skills needed today. There are four main pillars of 21st century skills, including creativity in scientific terms known as scientific creativity (Andres & Rosalinda, 2023; Astiningsih & Partana, 2020). These skills support the advancement of knowledge, especially in the field of technology (IPTEK) which is the main source in facing the challenges of the world of work. A person's success in the world of work is highly dependent on the knowledge and skills acquired during education (Dwikoranto et al., 2021; Sumo, Jatmiko, Supardi, et al., 2024). Education plays an important role in advancing a nation with quality Human Resources (HR) who are skilled in learning and able to innovate, thus enabling a nation to be proactive in facing global change (Arzak & Prahani, 2023; Güler, 2025). In the 21st century, Education aims to prepare students to become a superior generation that is religious, intelligent, independent, adaptive, competitive, and resilient in facing the challenges of the times (Andres & Rosalinda, 2023; Wibowo, 2023). Scientific creativity is very important in equipping students to be able to play an active role, collaborate, and produce creative solutions when solving various problems (Irma et al., 2023; Kartika et al., 2019; Park et al., 2023).

21st century skills are important for students to have, especially at the high school level in order to adapt to the increasingly advanced world (Andres & Rosalinda, 2023; Bahri et al., 2024; Kevin et al., 2024). The development of student potential in the 21st century is emphasized on 3 types of

competencies, namely: 1) learning skills (communication, collaboration, critical thinking, problem solving, creativity and innovation skills), 2) literacy skills (information, media and ICT mastery) and 3) life skills (flexibility, adaptation, initiative and independence) (Maharani Putri Kumalasani & Kusumaningtyas, 2022; Sumo, Jatmiko, Arifin, et al., 2024). One component of 21st century skills that students must have is creative thinking which is the basis of scientific creativity. This ability makes individuals produce something new, either in the form of ideas or products that are still related to existing products called creative thinking (Suradika., Dwi., 2023; Wahyuni & Rahayu, 2021). According to Park et al., (2023) stated that scientific creativity is an important thing related to problem solving skills and the creation of new ideas. Creative thinking skills are an important means to prepare oneself to face global challenges.

In reality, the scientific creativity of high school students, especially in physics, is still relatively low. This is evidenced by the results of research conducted by PISA in 2018-2022, where students' abilities in science are still at level 2 of the 6 levels needed for scientific creativity (PISA, 2023; Pusat Penilaian Pendidikan Balitbang Kemendikbud, 2019). Research conducted by Sumo, Jatmiko, Supardi, et al., (2024) showed that the scientific creativity of high school students in physics is still not as expected, this study was based on the results of scientific creativity tests that did not reach the minimum score required by the school. The results of this study were reinforced by preliminary research conducted by the researcher himself in January 2025 which found that out of 85 high school students whose scientific creativity was tested, it turned out that they were still below the minimum completion criteria.

The above problem, triggered by one of them is the learning process which tends to be monotonous so that students get bored in studying physics, this was expressed by students during interviews with researchers that physics learning only counts and memorizes certain formulas that are difficult and numerous. Therefore, this problem must be resolved immediately, considering the importance of creativity that every high school student must have as provisions after graduating so that they are able to compete in the world of work.

Learning innovation is needed to face the challenges as explained above, one of the learning innovations is through learning media and the use of innovative models and the integration of both. This is an effort to improve the scientific creativity of high school students, especially in physics subjects (Rahayu et al., 2022). The project-based learning model helps students explore, assess, interpret, synthesize, and collect information from several clear sources to produce creative products to solve real-life problems. According to Kartika et al., (2019) the project-based learning (PjBL) model is student-centered, emphasizing a more active and effective learning model that encourages students to solve problems independently and produce authentic work as a result of their learning (Dwikoranto et al., 2021). So by emphasizing the importance of integrating PjBL in education, it can improve superior skills in the era of the 5.0 revolution, in addition to creating a conducive learning environment will encourage students to actively think creatively and work together in solving problems. In other words, students are free to move and are active during learning by working on projects to create a product in groups. Students will be trained to be active in solving problems and describing the problems in class and collaborating with other students (Yurt, 2023; Zakaria et al., 2025).

The project-based learning model cannot stand alone in its application, therefore teaching materials are needed to support an effective learning process. One of the teaching materials that is often used is the Student Worksheet (LKPD). Student worksheets can encourage students to be more active, critical, and creative in the learning process and are one of the learning resources that support project-based learning (Arifullah, 2020; R. N. Ismail et al., 2020). In addition, the use of LKPD can change the learning pattern that is usually centered on the teacher to be more centered on students (Habibi et al., 2020). One of the advantages of project-based LKPD lies in its completeness with various elements and guides that make it easier for students to understand the material and solve problems (Rahmawati et al., 2021) . However, conventional LKPD still has limitations in presenting visualizations of abstract concepts and is less interactive in providing a deeper learning experience (Echle, 2021). These limitations can be overcome by integrating technology, one of the popular technologies in physics learning is Augmented Reality (AR). To overcome these problems, it is necessary to make efforts to change the learning process, one of which is the use of teaching materials integrated with technology.

One of the technologies in physics learning is AR. Augmented reality can change students' learning motivation to be more interested in physics because LKPD is able to present a more real learning experience, improve understanding of physics concepts, and train students' scientific creativity (Coban et al., 2025; Haim & Aschauer, 2022; Saphira, 2022). To support the use of AR, a learning model is needed in which there are problems that must be solved, one of which is the PjBL model. Based on the results of research conducted by Ellianawati et al., (2024) the PjBL model integrated with LKPD can help students learn effectively.

Based on the results of previous research studies, the application of LKPD in physics learning has been widely carried out (Baihaqi et al., 2021), as well as LKPD integrated with learning models including the PjBL learning model (Angelina et al., 2023). However, so far, LKPD for physics subjects that are integrated with AR technology and together based on the PjBL model in improving students' scientific creativity still does not exist. The novelty of this study is the integration between LKPD and AR based on the PjBL model to improve students' scientific creativity in physics subjects. This integration is based on theoretical and empirical studies of AR and the PjBL model. AR is one of the learning media that helps students gain real experience in the actualization of physics concepts (A. Ismail et al., 2024; Nugraheni & Mundilarto, 2022). While the PjBL model can improve students' scientific creativity at the secondary school and college levels (Sumo, Jatmiko, Arifin, et al., 2024). With this integration, it is a learning innovation that is able to answer the challenges of the industrial era 4.0 which is heading towards society 5.0 (Sumo, Jatmiko, Arifin, et al., 2024a).

The integration of the PjBL Learning model, LKPD, and Augmented Reality together in improving scientific creativity is unique in physics learning, this is due to the breadth of scientific creativity indicators as explained by Hu & Adey (2010) and developed by Torrance (Torrance, 2013) that scientific creativity does not only emphasize mastery of concepts (Suyidno et al., 2020) but scientific creativity is something new in finding concepts based on learning experiences from the discovery of phenomena in everyday life. This research aims to develop LKPD based on the AR-integrated PjBL Model which is reviewed from the validity and reliability of LKPD in improving students' scientific creativity in Newton's Law material. The LKPD developed is expected to be an innovative solution in physics learning, thus helping students understand concepts more deeply and interactively. In addition, this LKPD is designed to train creative thinking in a scientific context and can be applied in physics learning activities in schools.

2. METHODS

The method used in this study is Research & Development (R&D) from ADDIE. The selection of the ADDIE model is based on the research objectives and research steps. The research steps are, 1) Preliminary research, in this preliminary research consists of material analysis and literature study, this activity examines the relationship between the PjBL model and scientific creativity, 2) LKPD design, at this stage, the involvement of the PjBL model syntax and the scientific creativity approach becomes the main objective, 3) development, this development stage refers to the results of the problem analysis and the results of the preliminary study to improve scientific creativity, 4) Implementation, at this stage the application of the prototype is tested on high school students. This trial is to get an idea of the practicality of LKPD. The ADDIE model as the development of LKPD refers to several reasons: 1) the development steps are very clear, 2) systematic, and 3) directed (Celestino-Salcedo et al., 2024; Ida Kholida et al., 2020). In the LKPD development process from start to finish, this model development research leads to teacher productivity by producing relevant LKPD development products. Validation instrument is a tool to assess LKPD from the aspects of language, design, components and content. This instrument is designed to meet the validity criteria. To develop this instrument, first determine the objectives of the variables to be measured, second create a grid of the instrument aspects to be measured, the third validation process. There are three validators who are experts in the field of material, experts in the field of language, and experts in the field of physics learning technology. This study was only carried out up to the development stage, due to time constraints in the research process, so that the resulting LKPD products have not been widely implemented in the learning environment. the data analysis used is descriptive statistics with the help of Ms Excel and SPP 18. The following development model is used in Figure 1.

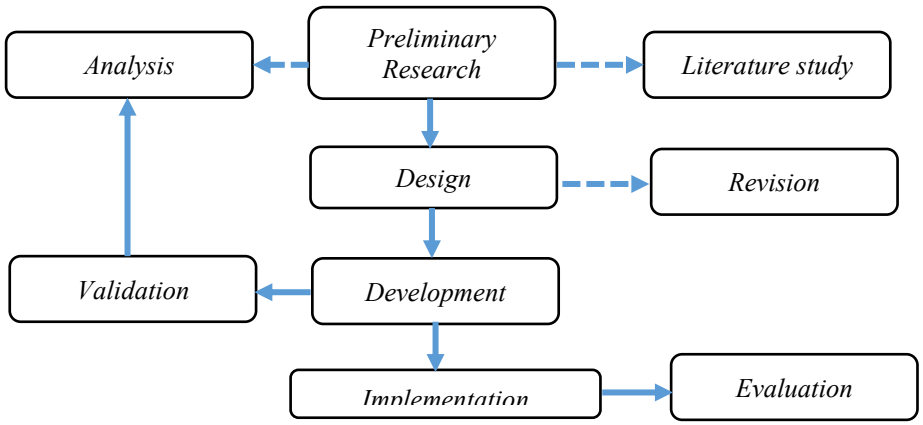


Figure 1. ADDIE Development Research flow diagram

Figure 1. Shows the ADDIE development model implemented in the development of Student Worksheets using three stages. The first stage in the development research is a preliminary study consisting of analysis of facts in the field and literature review of previous research including: competencies to be achieved, student characteristics, materials according to competency demands (Cynthia et al., 2023). The second stage is the design stage, at this stage the student worksheets are designed by following the development flow, Student worksheets designed are project-based and integrated with Augmented Reality (AR) on Newton's Law material. The design of this LKPD consists of the title of the activity, student identity, activity objectives, work instructions, relevant phenomena, Newton's Law material, project design draft, description of the student project design, preparing a schedule, project implementation, testing results, evaluation and adding interesting elements and colors to each page to increase student interest (Ismail et al., 2020; Siagian et al., 2019). The third stage of developing student worksheets is project-based and integrated with Augmented Reality. After being developed, validation is carried out by three experts in the fields of education, physics, and learning technology. The results of the validation are then analyzed for the level of validity and reliability. The validation data were then analyzed to determine the level of validity and reliability of the student worksheets integrated with AR. The analysis results were then adjusted to the criteria in Table 1.

Table 1. Validity Assessment Criteria for LKPD integration AR

Score Interval	Assessment criteria	Keterangan
3,25 ≤ VA < 4,00	Very valid	Can be used without revision
2,50 ≤ VA < 3,25	Valid	Can be used with minor revisions
1,75 ≤ VA < 2,50	less valid	Can be used with multiple revisions
1,00 ≤ VA < 1,75	Not valid	Not yet usable and requires consultation

Adapted from Sumo et al., (2024)

After calculating the validity score, the next step is to calculate the percentage of LKPD reliability. To calculate the percentage of reliability, use the formula from Borich et al. (1994).

$$R = \left(1 - \frac{A - B}{A + B} \times 100\%\right)$$

Information:
R : Reliability percentage LKPD
A : Reliability percentage
B : Lowest score from validator

After the reliability results were known, the reliability criteria from Borich et al. (1994) were then matched. The reliability criteria are shown in Table 2.

Table 2. Cronbach's alpha reliability interval

Alfa Cronbach	Calculation Result Criteria
$0{,}90 \leq \alpha \leq 1$	Very high
$0{,}70 \leq \alpha < 0{,}90$	High
$0{,}50 \leq \alpha < 0{,}70$	Moderate
$\alpha < 0{,}50$	Low

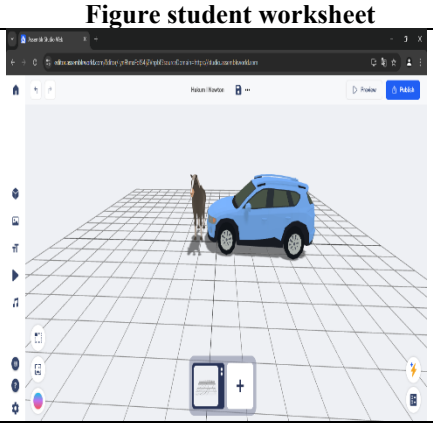
Source from Borich et al. (1994)

3. RESULT AND DISCUSSION

The results of the study in the form of validity from the results of the development of student worksheets integrated with augmented reality and based on a valid and reliable project-based learning model. The results of the validator's suggestions for revising the student worksheets are used as a reference by researchers in improving student worksheets based on the AR-integrated Project based Learning model. Suggestions for improvement are shown in Table 3.

Table 3. Suggestions for improving student worksheets based on the PjBL model integrated with AR

No	Suggestions for Improvement by Validator	Improvement results	
		Figure student worksheet	Description
1	The cover on the student worksheet is equipped with the learning model used.		Kaver is equipped with a project based learning model.
2	On the initial student activity page, it should be equipped with scientific phenomena that lead students to imagine.		In the student worksheet, the initial student activity is equipped with scientific phenomena related to Newton's 1st law, namely inertia.

No	Suggestions for Improvement by Validator	Improvement results	
		Figure student worksheet	Description
3	Simulations in augmented reality software should be adapted to scientific phenomena. Please use simulations as applications of Newton's 1st law.		Augmented reality software has been adapted to scientific phenomena as shown in the image on the side.

Suggestions for improvement from the three validators listed in Table 3 were used to improve the student worksheets and Augmented Reality applications. After the improvements were made, the validators then assessed the student worksheets and the applications used. By improving learning tools, it will support an effective learning process and will help teachers in delivering lesson materials more clearly (Costley et al., 2017). In addition, improving learning tools will have an impact on the effectiveness of learning and make it easier for students to understand learning materials (Wijayanto et al., 2020). In particular, good student worksheets will make it easier for students to achieve learning objectives, namely scientific creativity and innovation (Al-Kamzari & Alias, 2025; Cirkony, 2023). One of the supports for achieving scientific creativity is the existence of good learning instruments or tools (Prahani, Suprapto, Rachmadiarti, et al., 2021; Rahayu et al., 2022). The results of the assessment score calculations from the three validators were then averaged for each aspect using Excel and SPSS. The calculation results are shown in Table 4.

Table 4. Results of validation score calculations based on the assessment results of three validators.

Description of assessment aspects	Validity Assessment	
	Average Score	Criteria
Format:		
The arrangement of images and text in the student worksheets is proportional.	3,89	Very Valid
the text size conformity on each page is good	3,90	Very Valid
Content & language:		
Student worksheets are equipped with instructions for use and scientific phenomena.	3.77	Very Valid
use standard language	3.94	Very Valid
easy to understand language	4.00	Very Valid
Contextual:		
Student worksheets stimulate student creativity with Augmented reality technology	4.00	Very Valid

Based on the validation results in table 4, all aspects meet the validity criteria, both aspects of format, content and language, as well as aspects of context. The results of this validation indicate that the learning device created has met the validity and reliability criteria and can be used for certain learning purposes, this is in accordance with the opinion of (Plomp & Nieveen, 2013). That learning uses good instruments to achieve a goal. Valid and reliable instruments can measure good learning outcomes (Sumo, Jatmiko, Arifin, et al., 2024b; Suprapto & Hidaayatullaah, 2023; Xu et al., 2024). a good learning process is supported by valid learning devices (Octaviana et al., 2022;Ismail et al., 2020). From the validation results, the percentage of reliability is then calculated as shown in bar chart 1.

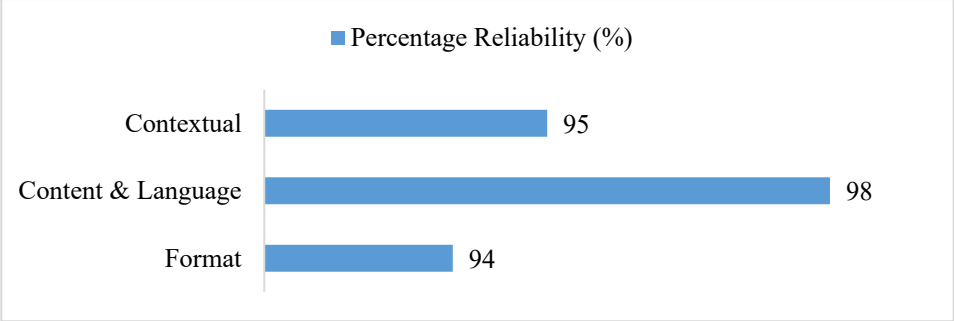


Figure 2. Percentage of reliability of student worksheets with AR based on the Project model

Figure 2, The percentage of LKPD reliability reviewed in terms of format got a percentage of 94%, meaning that three validators gave the same high assessment consistently to the LKPD format which includes the suitability of the LKPD image with the physics material and the size of the text is presented well. Meanwhile, the results of the assessment of three expert validators on content and language got a percentage of 98%, meaning that three validators assessed the content of the LKPD for its level of suitability with scientific phenomena and were equipped with instructions. In addition, the language used in the LKPD is very clear and operational. The Cronbach alpha percentage is 95%. The LKPD is designed according to everyday scientific phenomena, the material presented is in accordance with their interests and learning experiences. All percentages of reliability for each item have a reliability level of more than 0.75 or 75% with a very high category. This means that all items show consistent reliability and tend to measure the same construct consistently.

This reliability achievement shows that student worksheets integrated with Augmented Reality based on the project based learning model consistently have a good level of validity. These results are in line with research conducted by Zainuddin, et al (2020) and Arzak & Prahani, (2023) that the level of validity is in line with the reliability of a research instrument. Reliable instruments can be used to collect research data both quantitatively, qualitatively, and mixed. This is in accordance with statement Plomp & Nieveen, (2010) that reliable instruments can be used accurately to collect research data. This statement is in accordance with the results of research conducted by Irma et al., (2023) that reliable research instruments and learning tools will have a positive impact on learning outcomes. In addition, to measure the achievement of 21st century skills, it can be done through a learning process that uses learning tools that are in accordance with the validity and reliability criteria (Kevin et al., 2024).

The findings in this study are the results of the development of student worksheets based on the project-based learning model integrated with Augmented Reality technology are very valid and reliable. The relationship between validity and reliability, namely validity ensures that the LKPD instrument really measures the level of students' scientific creativity so that it is in accordance with the research objectives, while reliability ensures that the measurement of the level of validity of all LKPD items is consistent or stable so that it can be relied on to measure students' scientific creativity. The results of the validity exceed the minimum limit score of 2.5 with a reliability percentage of more than 75%. The validity and reliability of the LKPD sheet contribute to increasing students' scientific creativity in physics by ensuring that the tool provides consistent results (reliability), thus supporting deeper exploration of physics concepts and encouraging students' creative thinking. These findings provide recommendations that student worksheets for AR-integrated physics learning can be used for both small and large-scale research. In addition, these findings indicate that an innovative learning process using learning instruments or devices in the form of student worksheets can meet the objectives of 21st century learning (Cheli et al., 2023; Oktasari et al., 2019). Therefore, this student worksheet is one of the learning tools that can be used to measure the scientific creativity of high school students.

4. CONCLUSION

Based on the results of the study of the development of student worksheets using the ADDIE development model reviewed from the validity and reliability, it shows that the validation results show

that the Student Worksheet is classified as very valid and reliable with a score above 2.5, and a reliability percentage above 75%. This study is limited to the results of the development of student worksheets with valid and reliable categories, these student worksheets can be used or implemented in high schools. The implication of this study is that student worksheets can be used to improve scientific creativity. Scientific creativity can have an impact on improving the quality of learning, especially in the 21st century.

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