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**[Research Article]**

# PHYSICS ADVENTURE: AUGMENTED REALITY MEDIA WITH LOCAL CULTURAL CONTENT FOR PROJECTILE MOTION

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## ABSTRACT

This study aimed to develop Physics Adventure, an Augmented Reality (AR)-based learning media integrated with local cultural content on projectile motion material. The study employed a Research and Development (R&D) method using the ADDIE model consisting of analysis, design, development, implementation, and evaluation stages. The developed product was an interactive adventure-themed module integrating the Nias Stone Jumping culture with AR visualization to support students' understanding of projectile motion concepts. Media validation was conducted by four validators using the Learning Object Review Instrument (LORI). Data analysis was performed using Many Facet Rasch Measurement (MFRM) for expert validation results and the Rasch model for student evaluation questionnaire results. The analysis showed a validator reliability value of 0.87, with all validators categorized as fit to the Rasch model. The student evaluation results showed a Cronbach's Alpha value of 0.83, indicating good internal consistency of the instrument, while the person reliability value was 0.57, indicating a medium level of reliability in distinguishing students' response patterns. Most students responded positively to the developed media. Therefore, Physics Adventure was considered feasible as a physics learning media for projectile motion material.

Keywords: Augmented Reality, Local Culture, MFRM, Physics Adventure, Projectile Motion

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## 1. INTRODUCTION

Physics learning plays an important role in helping students understand scientific concepts, develop critical thinking skills, and build problem-solving skills. However, some physics concepts are still considered difficult to understand because they involve mathematical representation, vector analysis, and simultaneous visualization of abstract concepts (Srisawasdi & Kroothkeaw, 2021; Hwang & Chien, 2022). One of the physics topics that students often find difficult is projectile motion because it requires an understanding of the relationship between initial speed, elevation angle, trajectory, and visual representation of object movement (Pospiech et al., 2021). Difficulties in visualizing trajectories and directions of motion cause students to experience misconceptions and difficulty understanding concepts thoroughly, so physics learning is often considered less interesting and difficult to understand (Sánchez & Diaz, 2022). In addition, the concept of projectile motion also requires multi-representation interpretation skills that include graphs, mathematical equations, and simultaneous motion visualization (Umbara et al., 2022).

The development of digital technology provides opportunities to create more interactive and contextual physics learning through the visualization of abstract concepts. One of the technologies that has the potential to be applied in physics learning is Augmented Reality (AR). AR technology allows virtual objects to be visualized in three dimensions in a real environment thereby helping students understand abstract concepts through a more concrete and interactive learning experience (Lai & Cheong, 2022; Ibáñez & Delgado-Kloos, 2020). Previous studies have reported that the use of AR in physics learning can enhance students' learning motivation (Abdusselam & Karal 2020; Dewi & Kuswanto 2023). Research related to the use of AR in physics learning has also shown an increase in the trend of developing interactive media based on digital visualization in recent years (Dewi et al., 2021; Nurjanah et al., 2024; Wulandari et al., 2021). In addition, AR-based visualization also helps students understand motion concepts and vector representations that are difficult to observe directly through conventional learning (Thees et al., 2020). Other research has also shown that the application of AR in physics learning can improve learning outcomes and students' attitudes towards science learning (Fidan & Tuncel, 2019). In fact, AR is considered effective in supporting inquiry-based learning activities and visual exploration in modern STEM learning (Sirakaya & Sirakaya, 2022).

In addition to the use of digital technology, Integrating local culture into physics learning is also important to create a more meaningful and contextual learning experience. Cultural context-based learning can help students connect physics concepts with phenomena in daily life so that learning becomes closer to students' experiences (Sari et al., 2023; Rahmawati et al., 2024). One of the local cultures that is relevant to the concept of projectile motion is the Nias Stone Jump tradition. This tradition can be associated with the concepts of elevation angle, initial velocity, and projectile trajectory so that it has the potential to be used as a more interesting and contextual physics learning context.

In the context of projectile motion learning, the Nias Stone Jump tradition is represented using an idealized physical model. The jumper is assumed to be a point mass during the airborne phase, and the motion is analyzed in two dimensions. The initial velocity is decomposed into horizontal and vertical components, while gravitational acceleration is assumed to be constant. Air resistance is neglected so that the model focuses on the fundamental relationship between initial velocity, elevation angle, and projectile trajectory (Urone & Hinrichs, 2022). These assumptions are intended as a pedagogical simplification of the cultural phenomenon rather than a complete biomechanical representation of the actual jumping process.

Several previous studies have shown that AR-based learning media is able to improve the quality of physics learning through interactive visualization of abstract concepts (Lai & Cheong, 2022; Vidak et al., 2023). However, most research still focuses on the implementation of AR technology without integrating local cultural contexts in physics learning. In addition, the evaluation of media quality in previous research generally still uses simple descriptive analysis so that it has not been able to describe the quality of the instrument, the consistency of validator assessments, and the pattern of student responses in depth. Modern evaluation approaches such as the Many Facet Rasch Measurement (MFRM) and the Rasch model are still rarely used in research on the development of AR-based physics learning media. Therefore, it is necessary to develop contextual AR-based learning media and analyze it using modern measurement approaches to obtain more objective and comprehensive evaluation results (Linacre, 2024).

Based on these problems, this research developed an Augmented Reality-based Physics Adventure media with local culture content on projectile motion materials. The media was developed in the form of an adventure-themed interactive module that integrates the culture of Batu Jump Nias with AR visualization to help students understand the concept of projectile motion in a more contextual way. The novelty of this research lies in the development of AR-based physics learning media that integrates local culture and is analyzed using the Many Facet Rasch Measurement (MFRM) approach and the Rasch model to comprehensively evaluate the validity of the media and student responses. This research aims to develop Augmented Reality-based Physics Adventure media with local cultural content on projectile motion materials and analyze the validity of media and student responses using the Rasch approach.

## 2. METHOD

This research uses the Research and Development (R&D) method to develop Augmented Reality (AR)-based Physics Adventure learning media with local culture content on projectile motion materials (Creswell & Creswell, 2018). The development model used is ADDIE which consists of the analysis, design, development, implementation, and evaluation stages because this model has systematic stages in the development of learning media (Branch, 2009; Cahyadi, 2019). The stages of the research are presented in Figure 1.

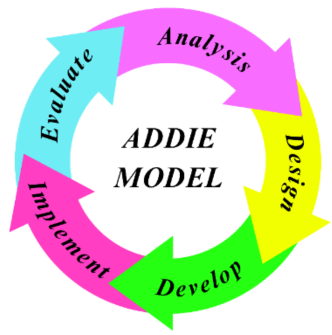


**Figure 1.** ADDIE Model Stages in Physics Adventure Development.

The research flow of Physics Adventure media development in this study is presented in Figure 2.

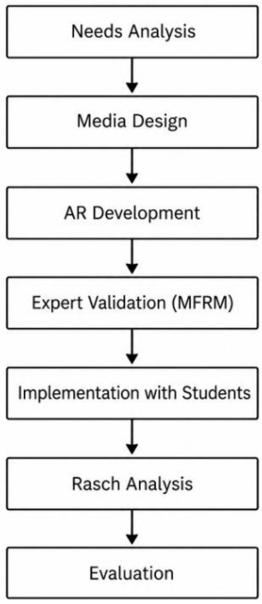


**Figure 2.** Physics Adventure Development Research Flow.

The analysis stage is carried out through literature study and needs analysis related to students' difficulties in understanding the concept of projectile motion. The design stage includes storyboard design, media displays, cultural integration of Batu Nias Jump, and QR Code-based AR visualization. The development stage is carried out by developing an AR-based interactive module using Assemblr. During the implementation stage, the developed Physics Adventure media was introduced to 31 high school students from grades XI and XII who had previously studied projectile motion. The students were selected purposively based on their grade level and prior experience with projectile motion. The implementation was conducted to obtain student responses to the developed media rather than to examine its effectiveness through a classroom learning intervention. After receiving brief instructions on how to access and use the media, students explored the media independently before completing the response questionnaire. The evaluation stage was carried out based on the results of expert validation and student responses to the developed media.

The product was validated by four physics education lecturers from Universitas Pendidikan Indonesia who have expertise in the field of physics learning and learning media development. The validation instrument uses the Learning Object Review Instrument (LORI) with a Likert scale of 1–5 which includes aspects of content quality, learning design, interactivity, and ease of use.

The validation data were analyzed using the Many Facet Rasch Measurement (MFRM) approach with the help of FACETS software based on reliability, separation, and fit statistics in the form of Infit and Outfit Mean Square (MNSQ) (Bond & Fox, 2015; Engelhard & Wind, 2018). Student response data was analyzed using the Rasch model with the help of MINISTEP software based on Cronbach Alpha scores, person reliability, separation, item fit statistics, and Wright map to determine the quality of the instrument and the consistency of student responses.

## 3. RESULT AND DISCUSSION

In this section, the discussion is focused on three main aspects, namely the results of the development of the Physics Adventure media, the results of expert validation using Many Facet Rasch Measurement (MFRM), and the results of student evaluation using the Rasch model. The discussion was carried out to determine the quality of the learning media developed and the students' response to the use of Augmented Reality (AR)-based media with local culture content on projectile motion materials.

### 3.1 Media Physics Adventure Development Results

The product developed in this study is in the form of Augmented Reality (AR)-based Physics Adventure learning media with local culture content on projectile motion materials. The media was developed in the form of an interactive module with an adventure theme that integrates the culture of Jumping Batu Nias with the visualization of physics concepts. Local cultural integration was implemented to create more contextual learning so that students can connect the concept of projectile motion with phenomena in daily life.

Media Physics Adventure is equipped with QR Code-based AR visualization that allows students to observe three-dimensional projectile motion simulations through digital devices. The visualization helps students understand the relationship between elevation angles, initial velocity, direction of motion, and trajectory of objects in a more concrete way. In addition, The media also includes visual illustrations, practice questions, and interactive learning activities to increase student involvement in the learning process.

The use of AR visualization allows students to dynamically observe the relationship between initial velocity, elevation angle, and projectile motion trajectory. The visualization helps students connect mathematical representations with more concrete concepts of motion that are often difficult to understand through conventional learning. Through interactive simulations, students can observe changes in the trajectory of projectile motion based on variations in initial conditions so as to help improve conceptual understanding and reduce misconceptions in projectile motion material.

The cultural integration of the Nias Rock Jump also supports contextual learning through an ethnophysical approach. The cultural context allows students to connect the concept of projectile motion with real phenomena contained in local traditions so that learning becomes more meaningful and relevant to students' daily experiences. The integration of local cultures also has the potential to increase student engagement and learning motivation because learning materials are associated with a socio-cultural environment that is close to students' lives.

The results of the development show that the use of AR is able to help the process of visualizing abstract concepts in projectile motion materials through interactive simulations. These findings are in line with the research of Lai and Cheong (2022) and Yu et al. (2023) who stated that AR-based media can improve students' understanding of concepts and engagement in physics learning. In addition, immersive visualization technology is also reported to be able to help the process of abstract representation of science concepts through a more interactive and realistic learning experience (Radianti et al., 2020; Parong & Mayer, 2021). The integration of local cultures also supports more contextual learning so that the concepts of physics become closer to the student experience.

**Figure 3.** Physics Adventure Module Display.


**Figure 4.** Augmented Reality Visualization on Projectile Motion Materials.

### 3.2 Expert Validation Results Using MFRM

Media validation was carried out by four expert validators using the Learning Object Review Instrument (LORI). Validation data analysis was carried out using the Many Facet Rasch Measurement (MFRM) approach with the help of FACETS software to determine the consistency of validator assessments and the suitability of instruments to the Rasch model.

The results of the analysis showed that the reliability value of the validator was 0.87 with a separation value of 2.61. These results indicate that the validators demonstrated a good level of consistency in assessing the developed media. In addition, all validators are in the fit category for the Rasch model based on the Infit and Outfit Mean Square (MNSQ) value which is close to 1.00.

**Table 1.** Validator Analysis Results Using MFRM.

| Validator | Measure | Infit MNSQ | Outfit MNSQ | Category |
|---|---|---|---|---|
| Validator 1 | 2,88 | 0,99 | 0.99 | Fit |
| Validator 2 | -1,81 | 0,95 | 0,95 | Fit |
| Validator 3 | 2,38 | 0,98 | 0,98 | Fit |
| Validator 4 | 3,39 | 0.99 | 0,99 | Fit |

Table 1 shows that all validators are in the fit category for the Rasch model with an Infit and Outfit Mean Square (MNSQ) value close to 1.00.

Validator 4 has the highest severity level with a logit value of 3.39, while Validator 2 tends to be looser in providing assessments with a logit value of -1.81.

**Table 2.** Validator Reliability Statistics.

| Parameter | Value |
|---|---|
| Separation | 2,61 |
| Strata | 3,81 |
| Reliability | 0,87 |
| Exact Agreement | 43,2 % |

The results of the analysis showed a reliability value of 0.87 with a separation value of 2.61. These findings indicate that the validators demonstrated good consistency of validators' assessments is in the good category.

A high reliability value of validators indicates that the validators provide a relatively consistent assessment of the quality of the developed media. This indicates that the validation instrument is able to distinguish the quality of the media objectively and consistently between validators. In addition, the fit statistics values in the accepted range indicate that the validation process has been in accordance with the Rasch measurement model.

Differences in severity levels between validators are common in Many Facet Rasch Measurement (MFRM) analysis because each validator has different assessment standards in conducting evaluations. However, all validators are still in the fit category so that the assessment process is considered to remain stable and reliable. Thus, the validation results can be trusted to determine the feasibility of the developed learning media.
The results of the FACETS vertical ruler show that there is a difference in severity between validators. Validator 4 has the highest level of severity, while Validator 2 tended to provide more lenient ratings. However, all validators are still in the fit category so that the assessment is considered consistent and in accordance with the Rasch measurement model.

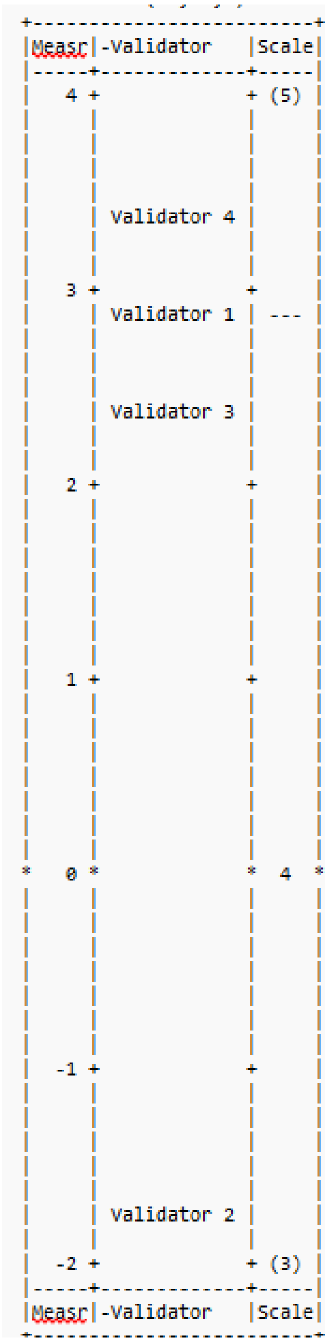

**Figure 5.** Vertical Ruler Validator Using FACETS.

Analysis of rating categories shows that all rating categories are functioning well. The MNSQ Outfit value in each category is close to 1.00 and the category thresholds are arranged in order. This shows that the validation instrument is able to distinguish the quality of the media consistently.

The validation results showed that the Physics Adventure media had good quality in terms of content, learning design, interactivity, and ease of use. This finding is in line with the research of Lai and Cheong (2022) who stated that AR-based learning media is able to improve the quality of visualization of abstract concepts in physics learning.

### 3.3 Student Evaluation Results Using the Rasch Model

The implementation stage was carried out to 31 high school students in grades XI and XII who had studied projectile motion materials. After using the Physics Adventure media, students responded through an evaluation questionnaire analyzed using the Rasch model with the help of ministep software.

The results of the analysis showed a Cronbach Alpha value of 0.83 which indicates that the evaluation instrument has good internal consistency. The person reliability value of 0.57 indicates that student responses tend to be homogeneous and dominated by positive assessments of learning media.

**Table 3.** Student Response Reliability Statistics.

| Parameter | Value | Interpretasi |
|---|---|---|
| Cronbach Alpha | 0.83 | Excellent |
| Person Reliability | 0.57 | Medium |
| Separation | 1.14 | Homogeneous response |

A high Cronbach Alpha score indicates that the evaluation item is able to measure student responses consistently. Meanwhile, the person reliability score in the medium category shows that most students provided relatively similar responses to learning media. This condition occurred because the majority of students responded positively to the use of Physics Adventure media.

The results of the item fit statistics analysis showed that most of the items were in the fit category with Infit and Outfit Mean Square (MNSQ) values in the accepted range. This shows that the evaluation item is able to measure student responses consistently according to the Rasch model.

**Table 4.** Item Fit Statistics Evaluation Questionnaire

| ENTRY NUMBER | TOTAL SCORE | TOTAL COUNT | JMLE MEASURE | MODEL S.E. | INFIT MNSQ | INFIT ZSTD | OUTFIT MNSQ | OUTFIT ZSTD | | PTMEASUR-AL CORR. | PTMEASUR-AL EXP. | EXACT MATCH OBS% | EXACT MATCH EXP% | Item |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 23 | 31 | 47.89 | 5.23 | 1.40 | 1.76 | 2.15 | 2.78 | A | .44 | .60 | 63.2 | 69.7 | P10 |
| 3 | 20 | 31 | 55.84 | 5.19 | 1.12 | .65 | 1.26 | .82 | B | .64 | .69 | 73.7 | 70.1 | P3 |
| 1 | 23 | 31 | 47.89 | 5.23 | 1.12 | .62 | 1.17 | .59 | C | .56 | .60 | 73.7 | 69.7 | P1 |
| 6 | 26 | 31 | 38.96 | 5.84 | 1.09 | .39 | 1.11 | .38 | D | .46 | .50 | 78.9 | 78.9 | P6 |
| 2 | 25 | 31 | 42.17 | 5.55 | .98 | .00 | .79 | -.39 | E | .55 | .53 | 73.7 | 75.7 | P2 |
| 7 | 24 | 31 | 45.12 | 5.35 | .93 | -.22 | .90 | -.16 | e | .59 | .57 | 78.9 | 72.1 | P7 |
| 9 | 21 | 31 | 53.19 | 5.15 | .91 | -.40 | .83 | -.45 | d | .69 | .66 | 73.7 | 69.2 | P9 |
| 5 | 24 | 31 | 45.12 | 5.35 | .82 | -.74 | .74 | -.65 | c | .63 | .57 | 78.9 | 72.1 | P5 |
| 4 | 16 | 31 | 67.99 | 6.11 | .75 | -.74 | .65 | -.37 | b | .84 | .79 | 84.2 | 80.5 | P4 |
| 8 | 20 | 31 | 55.84 | 5.19 | .67 | -1.80 | .59 | -1.30 | a | .78 | .69 | 84.2 | 70.1 | P8 |

The results of the Wright map show that most students are at a higher level of logit than the evaluation item. The findings showed that the majority of students responded positively to the Physics Adventure media developed.

The person reliability score in the medium category indicates that most students gave relatively similar responses to the developed learning media. This condition occurred because the majority of students gave positive assessments, resulting in relatively small variation in responses among students. However, this homogeneous positive response pattern may reduce response variability, thereby limiting the instrument's ability to distinguish different levels of agreement among students. Therefore, the medium person reliability value (0.57) should be considered a limitation of the instrument when interpreting individual differences in students' perceptions of the Physics Adventure media. Nevertheless, the findings indicate that the developed media was well received by students and was considered helpful in the learning process of projectile motion.

The results of the Wright map analysis showed that most students were at a higher logit level than the evaluation items, indicating that the items were generally easy to endorse and that students perceived the developed media positively, particularly in terms of visualization, interactivity, and ease of use.

At the item level, P4 had the highest measure (67.99), indicating the greatest endorsement difficulty. P4 concerns the flexibility of using different approaches to understand physics, suggesting that this aspect was relatively more challenging for students to endorse. In contrast, P6 had the lowest measure (38.96), indicating the easiest endorsement. As P6 concerns sharing responsibility in group tasks, this finding suggests that the collaborative aspect of Physics Adventure was readily accepted by students. P9 had an intermediate measure (53.19), indicating moderate endorsement of the module’s ability to support clear communication of physics concepts in discussions or presentations.

Overall, these findings indicate that Physics Adventure was positively received across the evaluated aspects, with its collaborative features being more readily accepted than the flexibility of using different approaches to understand physics.

The use of interactive AR visualization also has the potential to reduce students' cognitive load in learning projectile motion concepts because abstract concepts can be visualized more concretely through dynamic simulations. Students can observe the trajectory of motion directly and repeatedly, helping to understand the relationship between mathematical equations and physical phenomena in more depth.

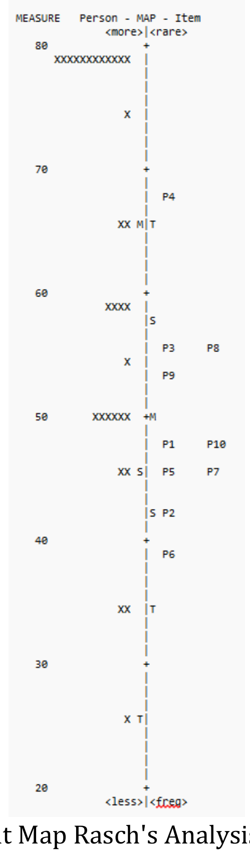


**Figure 6.** Wright Map Rasch's Analysis.

In addition to the quantitative data, the results of the evaluation showed that students responded positively to the use of Physics Adventure media. Students stated that AR visualization helps to understand the concept of projectile motion in a more concrete way and makes learning physics more interesting. These findings are in line with the research of Yu et al. (2023) who stated that the use of AR can increase students' engagement and understanding of concepts in physics learning. Other research has also shown that AR-based physics learning media can increase learning motivation and learning effectiveness through more engaging interactive visualizations (Dewi & Kuswanto, 2023; Kartika et al., 2024).

### 3.4 Research Implications

The results of this study show that Augmented Reality (AR)-based learning media integrated with local culture can support more interactive and contextual physics learning. The use of AR technology allows abstract concepts in projectile motion materials to be visualized more concretely, helping to improve students' understanding of concepts. In addition, the integration of local cultures through an ethnophysical approach can help students connect physics concepts with real experiences and cultural practices found in the surrounding environment.

### 3.5 Research Limitations

This study is still limited to a relatively small number of participants and only focuses on the analysis of media feasibility and student responses to the developed product. The effectiveness of media on improving students' understanding of concepts and learning outcomes has not been analyzed in depth. Therefore, further research is recommended to conduct experimental research with a larger sample number and involve measuring learning outcomes to test the effectiveness of the AR-based learning media developed.

## 4. CONCLUSION

This research develops an Augmented Reality (AR)-based Physics Adventure media with local culture content on projectile motion materials using the ADDIE model. The validation results using the Many Facet Rasch Measurement (MFRM) approach showed that The media was categorized as feasible for use in physics learning with all validators included in the fit category for the Rasch model. In addition, the results of the students' evaluation showed a positive response with the consistency of the instrument being classified as good.

The results indicate that the integration of AR technology and local culture can support more interactive and contextual physics learning and help the process of visualizing abstract concepts in projectile motion materials. Therefore, Physics Adventure media has the potential to be used as an alternative to digital technology-based physics learning media in schools. Future studies are recommended to test the effectiveness of media on improving students' understanding of concepts, learning outcomes, and higher-level thinking skills in physics learning.

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