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Development of Gamification-Based Learning Media on Atmospheric Dynamics Material

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Abstract

This development research aims to produce a gamification-based learning media that is feasible and effective for teaching the topic of atmospheric dynamics and its impact on life in Geography subjects. The material on atmospheric dynamics and its impacts includes several subtopics, namely: (1) identifying the layers of the Earth's atmosphere, (2) analyzing weather elements and interpreting weather data, (3) identifying atmospheric dynamics and their impact on life, (4) analyzing the classification of climate types and global climate patterns, and (5) understanding the characteristics of Indonesia's climate and its influence on human activities. This research explains that gamification does not mean creating a game, but rather developing specialized media to apply gamification concepts more effectively. The development of the media was carried out using the Research and Development (R&D) method with the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). This study produced learning media containing gamification elements such as points, badges, challenges, competition, collaboration, levels, content unlocking, duration, tasks, and game rules. The model used in the implementation of this gamification-based learning media is the Game-Based Learning model. Data collection techniques in this research used questionnaires with a Likert scale. The results obtained showed a validation score from media experts of 89%, from material experts of 83%, and students' trial results reached 83% as well. Therefore, the gamification-based learning media is categorized as "highly feasible" for use.

Keywords: Learning media, Gamification, Atmospheric Dynamics

INTRODUCTION

The advancement of information and communication technology is an inevitable aspect of life, as it progresses alongside knowledge development. Every innovation and discovery is created to provide ease and positive benefits for human life (Sutrisna, 2021). In education, information and communication technology development plays an essential role in supporting the teaching and learning process (Sari & Rosdiana, 2024). One of the most prominent uses of technology is as a learning medium, including geography subjects at the senior high school level.

The role of Geography as a subject in education is to develop students' understanding of spatial organization, communities, places, and environments on Earth (Sumaatmadja, 1988). Generally, learning media are tools or platforms used to deliver messages in the teaching and learning process to clarify the meaning of the messages conveyed from the source to the receiver (Muhson, 2010). This means that learning media encompasses everything teachers use to facilitate the explanation of the subject matter to students. In the teaching and learning process, the use of learning media must be carefully considered because the appropriate use of media can help both teachers and students achieve learning objectives as expected, making the learning process more effective and efficient (Audie, 2019).

One of the topics studied in Geography at senior high school is atmospheric dynamics and its impact on life. This is an essential topic that students need to understand so that it can be applied in daily life. There are five subtopics discussed within this material. Based on this, it is

necessary to conduct a needs analysis before determining what kind of learning development is needed in the field. Boroujeni and Fard (2013) argue that needs analysis helps evaluate existing programs. If deficiencies are found, it can help identify the necessary needs, introducing changes that may suit students' needs.

Previous studies have shown that gamification engages students actively in learning (Srimuliyani, 2023). Other studies reveal that gamification-based learning media can significantly impact students' learning experiences, even resulting in better evaluation scores (Srimuliyani, 2023). This proves the role of gamification-based learning media as an evaluation tool that utilizes modern technology to foster students' learning interest, enhance critical thinking skills, and contribute to character building. Therefore, the existence of gamification-based learning media is expected to respond to technological advancements by improving students' critical thinking abilities. In the Modern Psychological Studies Journal of the University of the Cumberlands, Smyth suggested that complex gaming methods can lead to academic success by engaging players in problem-solving, creativity, and critical thinking (Rahmadila et al., 2019).

This study explains that gamification does not mean creating a complete game but instead developing specific media that apply the concept of gamification more effectively. It should be understood that gamification is not about creating games but developing learning media that adopt game elements to enhance learning effectiveness (Jufrida et al., 2019). Educational game applications aim to encourage students to solve problems in specific subjects by completing exercises or simulations contained within the application. Therefore, this gamification-based learning media can facilitate students' understanding of learning materials, particularly the topic of atmospheric dynamics and its impact on life.

RESEARCH METHODS

The type of research used in this study is Research and Development (R&D). The development of this gamification-based learning media employs the ADDIE development model, which consists of Analysis, Design, Development, Implementation, and Evaluation phases (Lee & Owens, 2004). The procedures for developing learning media using the ADDIE development model are as follows.

Table 1. Procedures for Developing Learning Media Using the ADDIE Model

No	ADDIE Phase	Activities
1.	Analysis	1. Analysis of curriculum, materials, and student needs 2. Analysis of existing learning media 3. Analysis of supporting resources
2.	Design	1. Creating a storyboard 2. Preparing materials, videos, and questions 3. Developing media assessment instruments
3.	Development	1. Developing the learning media product 2. Validation by media experts and material experts
4.	Implementatation	Product trial on research subjects
5.	Evaluation	Formative and summative evaluation, as well as product dissemination

(Source: Data Processing, 2025)

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RESULTS AND DISCUSSION

1. Gamification Elements and Learning Material

Using media with a gamification concept is ideal for learning because it incorporates gamification elements that can significantly impact users. Several elements must be implemented in the development of gamification. According to (Marczewski, 2015), the periodic table of gamification elements presents 52 gamification elements, as shown in Figure 1.

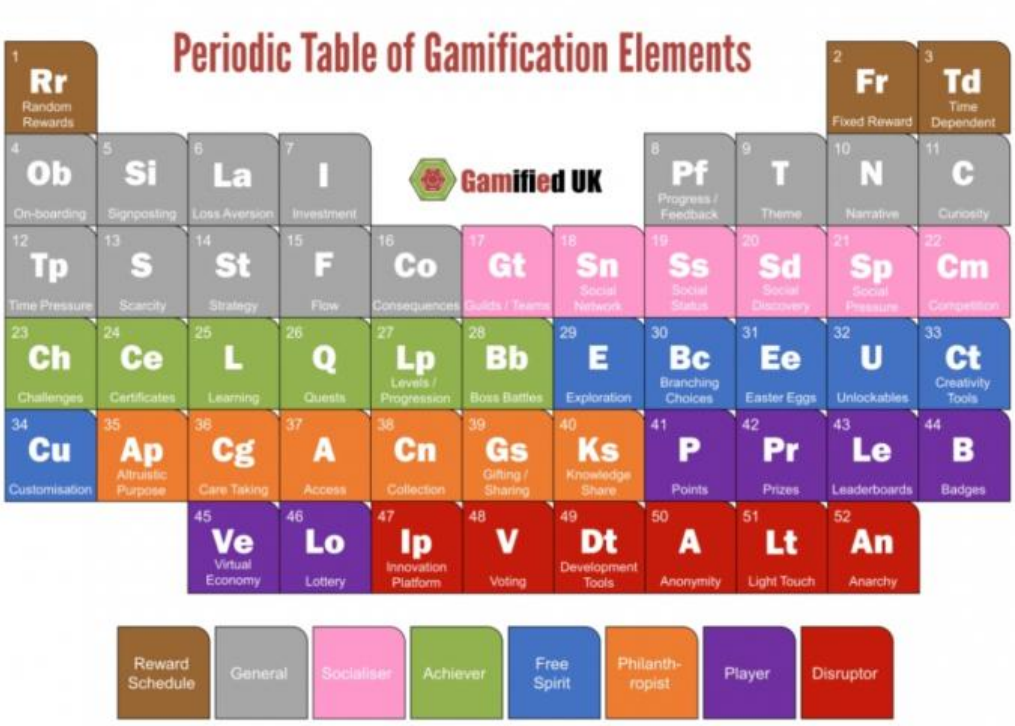

Figure 1. Gamification Elements (Source: Data Processing, 2025)

Gamification has many elements that can be implemented in the learning process. There is no specific guideline for implementing these gamification elements in learning (Julianto & Ekohariadi, 2020). In developing this gamification-based geography learning media, only ten gamification elements were selected as the most important and suitable for the needs of geography learning media, namely: (1) Challenges, (2) Points, (3) Badges, (4) Content Unlocking, (5) Competition, (6) Collaboration, (7) Game Rules, (8) Levels, (9) Tasks, and (10) Duration. The selection of these elements considers students' active engagement in completing tasks and receiving meaningful feedback, as explained by (Finamore et al., 2021), who stated that motivation in gamification emerges through reward systems, challenges, and social interaction.

The topic of atmospheric dynamics and its impact on life consists of several subtopics, including (1) identifying the layers of the Earth's atmosphere, (2) analyzing weather elements and interpreting weather data, (3) identifying atmospheric dynamics and their impact on life, (4) analyzing climate type classifications and global climate patterns, and (5) understanding the characteristics of Indonesia's climate and its influence on human activities (Br Butar-Butar & Arif, 2024). The learning objectives using gamification-based learning media guide students to observe (read), overcome challenges, and understand the material during and after the learning process. After completing this learning, students are expected to be able to identify the

characteristics of atmospheric layers and their utilization, explain the elements of weather and climate, describe climate classifications, explain the distribution of rainfall in Indonesia, observe rainfall distribution maps in Indonesia and Southeast Asian countries, and explain the factors causing global climate change (El Niño, La Niña) and their impacts on life (Finamore et al., 2021). This study includes all subtopics in the chapter packaged into one application to facilitate students' receiving the learning material engagingly and innovatively.

2. Media Development Stages

Analysis Stage

The material analysis conducted revealed that: (1) The topic of atmospheric dynamics and its impact on life is a material that covers spatial concepts, namely the influence and dynamics of the atmosphere on life (Br Butar-Butar & Arif, 2024) ; (2) The material has an informative characteristic, so in the learning experience, students mostly read and observe the delivered material, thus requiring an attractive informative learning media, such as game-based media to make it easier to understand or visual media such as images, tables, diagrams, maps, videos, and infographics (Khoiruddin & Iskandar, 2024); (3) The topic of atmospheric dynamics and its impact on life discusses many aspects of the Earth's atmosphere, such as its layers, air pressure, temperature, climate, as well as their influence and dynamics on life (Safitri et al., 2022).

A needs analysis was conducted involving geography teachers and 34 students through questionnaires. The results showed that 60% of students still perceived this subject as complex and uninteresting. This difficulty arises from textbooks that lack illustrative images, are relatively unengaging, and present incomplete material content. These difficulties result in: (1) Slower teaching and learning activities, (2) Longer learning times as teachers need to repeat the material, and (3) Students being unable to achieve the expected competencies simply and efficiently (Finamore et al., 2021). Therefore, there is a need for more engaging learning media or resources with complete material content to minimize students' difficulties in learning.

Design Stage

At this stage, the researcher determined the design of interactive learning media using PowerPoint. The product design must be adjusted to students' and teachers' characteristics and needs, and include gamification elements. The gamification-based learning media was later named "Who Wants to Be an Astronaut." This platform takes the form of a web-based application containing various features and media

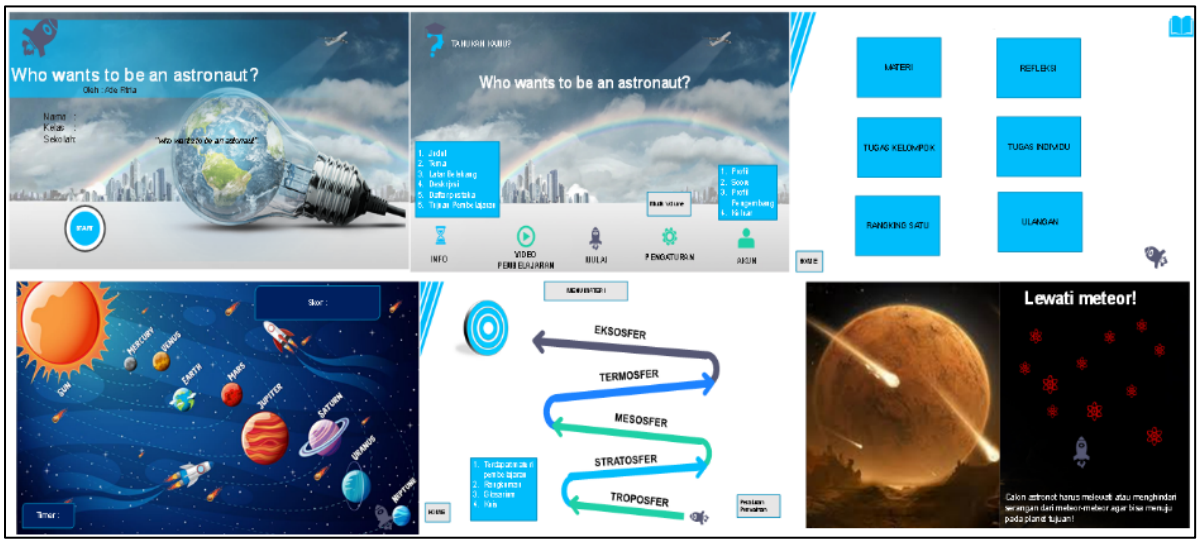

Figure 2. Initial Design of Gamification Media Development (Source: Data Processing, 2025)

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3. Development Stage

At the development stage, two aspects need to be prepared: the development of the gamification-based learning media and the development of media validation instruments.

Development of Gamification-Based Learning Media

The researcher developed the media based on the storyboard and design that had been created. This gamification-based learning media can be used anytime and anywhere on any digital device. It can be accessed as a web or application without downloading and can also be used offline. The gamification-based learning media contains material on atmospheric dynamics and its impact on life. It has gamification elements and features such as a learning objectives menu, material, videos, games, quizzes, project tasks, individual tasks, glossary, tests, and reflections. Students can immediately complete challenges, work on questions, and submit assignments using this gamification-based learning media.

Students enter their identity information on the opening menu to access the media. The initial menu display also shows several accessible menus that can be selected, such as learning objectives, videos, scores, explanations of the game's name, the developer's name, and other supporting menus. By selecting the 'start' menu on the main page, players can begin to play the game.

Figure 3. Media Opening Display (Source: Data Processing, 2025)

Figure 4. Main Menu Display (Source: Data Processing, 2025)

Next is the content display, which guides the sequence of rooms players must pass through. This display presents six menus consisting of material, reflection, "ranking one," project tasks, individual tasks, and concludes with the test menu. The material menu explains atmospheric dynamics, a topic for grade X in senior high school. This material was chosen because the needs analysis showed that atmospheric dynamics and their impact on life are complex for students to understand. The material is presented in images and text, followed by quizzes in the form of questions to complete the existing missions. Players cannot proceed to the next level without completing the available challenges.

Figure 5. Material Menu (Challenge) (Source: Data Processing, 2025)

Figure 6. Test Menu (Challenge) (Source: Data Processing, 2025)

Development of Media Validation Instruments

The researcher developed an instrument to test the validity of the product that had been developed and to measure the feasibility of the resulting product. The product trial discussion covers several aspects, including trial design, trial subjects, types of data, data collection instruments, and data analysis techniques. The instrument used was a questionnaire with a Likert scale (1–4), which was distributed to media experts, material experts, and students as validators.

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Table 2. Likert Scale

No	Response Scale	Score
1.	Strongly Agree	4
2.	Agree	3
3.	Disagree	2
4.	Strongly Disagree	1

(Source: Joshi et al., 2015; Taherdoost, 2019).

The media expert questionnaire instrument included the following criteria: (1) Software, with items covering maintainability, usability, compatibility, multimedia operation, design, feature completeness, evaluation, background suitability, and alignment with learning objectives; (2) Visual Quality, with items covering the appropriateness of font size and type, accuracy of images and videos, clarity of writing, and menu tools. The material expert questionnaire instrument included the criteria of (1) Content Quality and Objectives, (2) Instructional Quality, (3) Technical Quality, and (4) Question Quality. The student questionnaire instrument included (1) Perception, (2) Learning Habits, (3) Interest and Motivation, (4) Learning Methods, and (5) Learning Media Preferences.

The developed learning media were tested by media experts, material experts, and students. This trial was conducted to determine the validity level of the developed media. After the product was produced, validation activities were carried out to test its validity, with validation sheets given to the validators for assessment.

Table 3. Product Qualification

Average Score Percentage	Category	Description
85%-100%	Highly Feasible	Very Good
69%-84%	Feasible	Can be used with minor revisions
53%-68%	Fairly Feasible	Can be used with major revisions
37%-52%	Less Feasible	Should not be used
20%-36%	Not Feasible	Should not be used

(Source: Modified from Akbar, 2013)

The product validation activity was carried out to ensure that the developed product was more refined and feasible for trials with subjects. The following is the trial scheme for developing gamification-based learning media on atmospheric dynamics and its impact on life.

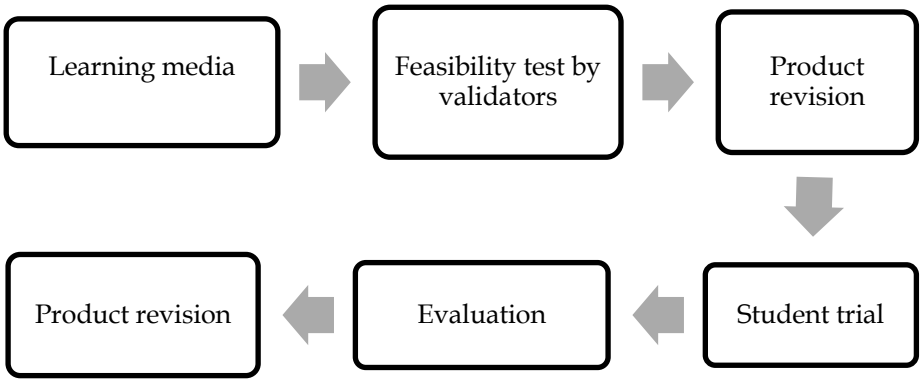

Figure 7. Product Trial Design Chart (Source: Data Processing, 2025)

Expert Validation Results

The expert validation results are data from the validation questionnaires completed by two expert validators in their respective fields. Two expert validators were required: a media and material expert validator. Table 4 below presents the assessment results from the media expert validator for the developed gamification-based learning media.

Table 4. Media Validation Results

No	Aspect	Number of Statements	Total Questionnaire Score	Maximum Possible Score	Percentage per Aspect	Qualificatiom
1	Software	10	39	40	98%	Gighly Feasible
2	Visual Quality	10	32	40	80%	Feasible
Amount		20	71	80	89%	Highly Feasible

(Source: Data Processing, 2025)

The validation results comprised assessments of the developed media product and suggestions or comments regarding the gamification-based learning media. Based on the validation results from the media expert validator presented in Table 4, the learning media received a score of 89%. In the software aspect, it scored 98% with a qualification of "highly feasible," and in the visual quality aspect, it scored 80% with a qualification of "feasible." Therefore, the media expert validation concluded that the gamification-based learning media was "highly feasible" for use.

Table 5. Material Validation Results

No	Aspect	Number of Statements	Total Questionnaire Score	Maximum Possible Score	Percentage per Aspect	Qualificatiom
1	Content Quality and Objectives	4	12	16	75%	Feasible
2	Instructional Quality	5	18	20	90%	Highly Feasible
3	Technical Quality	5	17	20	85%	Highly Feasible
4	Practice Exercises	6	19	24	79%	Feasible
Amount		20	66	100	83%	Highly Feasibl

(Source: Data Processing, 2025)

The validation results consisted of assessments of the material coverage in the media, along with suggestions or comments regarding the gamification-based learning media material. Based on Table 5, the material validation results showed a score of 83% with a qualification of "highly feasible." There were four aspects assessed in the media material. The content quality and objectives aspect received a score of 75% with a qualification of "feasible." The instructional quality aspect scored 90% with a qualification of "highly feasible." The technical quality aspect scored 85% with a qualification of "highly feasible." The last aspect, question quality, scored 79% with a

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qualification of "feasible." These results conclude that, based on validation, the media product was declared highly feasible.

4. Implementation Stage

At this stage, the researcher conducted trials on the research subjects, grade X geography students. The product trial stage was carried out to determine the feasibility of the learning media. The trial involved 33 students. Quantitative data were obtained through questionnaires and test instruments. The instruments were distributed via Google Forms to allow the collected data to be easily classified. The quantitative data were derived from the calculation of questionnaire and test scores completed by the students. The data collected included media product development assessment scores and test result scores.

The trial questionnaire was completed after the students used the gamification-based media product. The product trial questionnaire included three aspects: appearance, material presentation, and usability, each consisting of five assessment items. The feasibility test results of the gamification-based media conducted with the students are presented in Table 4.5.

Table 6. Media Feasibility Test Results

No	Aspect	Number of Statements	Total Questionnaire Score	Maximum Possible Score	Percentage per Aspect	Qualificatiom
1	Appearance	5	573	620	84%	Highly Feasible
2	Material Presentation	5	566	620	85%	Highly Feasible
3	Usability	5	558	620	84%	Highly Feasible
	Amount	15	1697	2040	83,2	Highly Feasible

(Source: Data Processing, 2025)

The trial conducted with students aimed to determine the feasibility of the developed learning media. Based on the feasibility trial results, the media obtained a percentage score of 83%, assessed from three aspects: appearance scored 84%, material scored 85%, and usability scored 84%. Thus, the gamification-based learning media had an average score of 83.2% with the "highly feasible" qualification for use.

The feasibility of this gamification-based learning media is that its use in this study provided excitement and enjoyment for students as they completed the game interactively. They could control the player to collect scores, overcome obstacles, and compete with other groups to finish the game as quickly as possible. Using educational games in learning can increase students' interest in learning and encourage them to be directly involved in the learning process (Wijaya, 2022). This aligns with Divjak's (2011) opinion that games can stimulate students emotionally, intellectually, and psychomotorically. Therefore, respondents in the media feasibility test felt that the gamification-based learning media could be implemented in the classroom, resulting in high percentage scores in data analysis.

In addition, the obstacles presented in this educational game take the form of guiding questions that serve as a basis for solving contextual problems presented by the teacher during learning activities. Correct answers to these questions as obstacles can increase the player's score in the game. However, if students provide

incorrect answers, they must reread the material. This situation certainly encourages students to fully concentrate on completing each challenge in the game to avoid failure. Gamification media encourages students' extra effort and focus to solve problems (Boroujeni & Fard, 2013). This gamification-based learning media is also easy to operate, making its functions quickly understood by students. The learning media have features according to the applied gamification elements and are very practical for independent learning. The educational game media developed with independent learning features allows students to be directly involved in learning (Jusuf, 2016). Students who do not fully understand the material can play the game while studying at home.

5. Evaluation

There are two types of evaluation: formative evaluation and summative evaluation. In this study, formative evaluation aimed to assess the product based on feedback and suggestions. The primary purpose of the summative evaluation was to determine the feasibility and effectiveness of the developed media (Supriyono, 2018). The technique used at this stage included questionnaires. Formative evaluation at each stage of this research development included, in the analysis stage, suggestions to broaden the scope of analysis, including material analysis, needs analysis, support analysis, and analysis of media development requirements. At the planning stage, the evaluation involved feedback on the media design created by the researcher. During the development stage, advisors obtained evaluations regarding the addition of gamification elements and materials, followed by expert validation and individual trials with students, resulting in several evaluations for the developed product.

Summative evaluation was conducted at the end of the product development stages. This evaluation was based on feedback obtained by the researcher during the product implementation stage, consisting of suggestions and input from students used for evaluation purposes. This evaluation stage aimed to determine the feasibility and effectiveness of the developed gamification-based learning media. In terms of media feasibility, based on the product trial results, the gamification-based learning media on atmospheric dynamics and its impact on life was deemed feasible for use, with a percentage score of 83% and a qualification of "highly feasible." This was supported by validation results from media and material experts, which indicated that the gamification media was highly feasible for use with some suggestions provided.

Summative evaluation is conducted to answer whether the produced product or program is good quality (Hadiyastama et al., 2022). The decision determines whether to continue using the learning media (Warsita, 2008). In answering this, the gamification-based learning media has passed the implementation stage to determine its feasibility for students. Based on the analysis of the students' questionnaire data, it was found that the media scored 83.2% with the qualification of "highly feasible." Therefore, in answering the summative evaluation decision regarding effectiveness, it was concluded that the gamification-based learning media is feasible and effective to be used as learning media in the classroom. Both teachers and students can widely use the developed product as a medium in learning activities. This media product development has undergone various stages of improvement and has received quite good evaluations and effectiveness testing on students' critical thinking skills. The developed product has several advantages and disadvantages that need to be considered, including:

Product Advantages

Based on the product that has been developed and tested, the developed product has the following advantages:

a) The developed product can be used as software and applies to PCs/laptops and smartphones.
b) The resulting product contains the entire material on atmospheric dynamics and its impact on life.
c) The gamification-based learning media product can be used anytime and anywhere without an internet connection.
d) The resulting product can serve as a supporting medium for learning activities in geography subjects.

Product Disadvantages

The developed product also has some disadvantages, namely that this learning media application cannot be used on iOS devices and is available only in one language, Indonesian.

CONCLUSION

This study developed a gamification-based learning media named "Who Wants To Be An Astronaut," which contains material on atmospheric dynamics and its impact on life. This gamification-based learning media, in the form of an application, is equipped with digital features utilizing gamification elements and can be used on all types of digital devices, both online and offline. The media validation results showed a percentage score of 89% with a qualification of "highly feasible." In comparison, the material validation results showed a percentage score of 83% with a qualification of "highly feasible." The feasibility trial results with students showed a percentage score of 83% with a qualification of "highly feasible." Therefore, it can be concluded that developing this gamification-based learning media is highly feasible for use.

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