



Development of Learning Instruments Based on Game-Based Learning Assisted by Baamboozle Educational Game on Digestive System Material to Improve Students' Learning Outcomes

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Abstract

This study focuses on the development of game-based learning instruments using the Baamboozle educational game for teaching digestive system material to eleventh-grade students. The need for this study arose from observations and interviews conducted with biology teachers at Hang Tuah Belawan Private High School, which revealed that the traditional teaching methods currently employed are ineffective in enhancing student interest and comprehension of complex digestive system material. The research methodology used in this study is the Four-D development model (Define, Design, Develop, Disseminate), which falls under the umbrella of development research or research and development (R&D). Data were collected through interview sheets, expert validation sheets, questionnaires for students and teachers regarding the use of learning instruments, as well as pretest and posttest sheets to evaluate effectiveness. Data analysis was conducted using the Likert scale, and the results were categorized based on the scale's interpretation criteria to conclude the validity, practicality, and effectiveness of the instruments. The findings indicate that the game-based learning instruments developed using Baamboozle games are highly valid, practical, and effective. This study makes a valuable contribution to the advancement of innovative teaching methods that combine educational game technology with complex biological concepts. The implications of this study are significant for future research and practice in educational technology, particularly in terms of enhancing student engagement, promoting the creation of interactive game-based learning content for various subjects, and exploring the long-term effectiveness of game-based learning in science education at the secondary level.

Keywords: Learning Instruments; Game Based Learning; Baamboozle

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INTRODUCTION

In the era of the 4.0 revolution, there has been a significant shift in education towards the incorporation of digital learning processes, utilizing technology and the internet for learning activities within schools (Gading, 2020). The integration of technology as a medium for education has become necessary in the present day due to its effectiveness, efficiency, and capability to engage and promote creativity among students (Kurniawati et al., 2019). Recent research in the field of biology education further supports this development. Atikah et al. (2023) conducted a study on the utilization of the V-Lab (Virtual Laboratory) application for android-based catalase enzyme tests, finding that it not only served as an alternative platform for practical laboratory work but also enhanced student motivation and learning outcomes.

Moreover, a meta-analysis conducted by Karlina et al. (2022) confirmed the significant impact of biology educational game-based learning media, centered on Higher Order Thinking Skills (HOTS) questions, on students' science literacy skills. As a result, the digital revolution in biology education not only provides more engaging and efficient learning methods but also facilitates interactive learning experiences.

However, it is important to acknowledge the challenges faced by schools and teachers in Indonesia. Research conducted by Suyamto et al. (2020) reveals various issues, including the standards of teachers, their mastery of subject materials, and the lack of media and technology literacy. The Indonesian Minister of Education and Culture's Regulation number 22 of 2016 establishes that the systematic, integrated, and effective use of information and communication technology, tailored to the specific circumstances and conditions, is a fundamental principle in designing the Learning Planning Design (RPP). Adhering to this principle is essential for enhancing the efficiency and effectiveness of the learning process (Permendikbud No. 22 of 2016 Appendix). Biology learning presents significant challenges in terms of comprehensibility and complexity. Nonetheless, biology holds great significance due to its relevance to daily life. One notable area is the study of the digestive system. Conventional teaching methods employed in this subject often fail to engage students, resulting in reduced focus on the teacher's explanations and limited understanding of the concepts being discussed (Dwi Puspa, 2022). Consequently, this lack of comprehension adversely impacts students' academic performance.

To tackle this issue head-on, game-based learning has emerged as a highly effective solution (Risky Amelia & Hajar, 2024). This approach aims to address students' lack of interest and comprehension by presenting intricate biological concepts in a more captivating and interactive manner. By incorporating enjoyable game elements, this method enhances students' motivation to learn. A prime example of this can be observed in the study by Azzahra et al. (2023), where a simulation game depicting the digestive process successfully substituted the traditional lecture format. Through such simulations, students gain the opportunity to witness and experience the digestive process firsthand, thereby making abstract concepts more tangible and easier to grasp.

The integration of game-based learning directly confronts the issues of student disengagement and difficulty concentrating. This approach not only fosters a more dynamic learning environment but also encourages active student participation. Ultimately, it facilitates a deeper understanding of the complexities of the digestive system. According to Made et al. (2023), Game Based Learning (GBL) is an active learning approach that aims to improve students' knowledge and skills by engaging them in the learning process. GBL is expected to facilitate students' understanding of the subject matter in an enjoyable, comfortable, and meaningful way. The implementation of GBL in biology education allows students to actively participate in their own learning experiences. GBL is specifically designed to strike a balance between theoretical content and the utilization of educational games. This method enables students to explore challenging learning environments and concepts, facilitating targeted learning outcomes (Adipat et al., 2021).

Winatha and Setiawan (2020) identify several benefits of employing GBL, including: 1) enhancing student engagement and motivation, 2) fostering the development of literacy and numeracy skills, 3) serving as a therapeutic tool to overcome cognitive difficulties, 4) providing students with the opportunity to simulate real-life roles or professions, and 5) empowering students to create multimedia and game-based content.

The effectiveness of GBL has been supported by research conducted by Sulistiyohadi (2021) at MTsN 7 Ngawi school. This study investigated the application of GBL in teaching the digestive system in biology and found that it resulted in a 30.44% increase in student activity and a 21.74% improvement in learning outcomes. Furthermore, GBL plays a crucial role in influencing learner motivation, promoting a sense of happiness, excitement, challenge, and fostering cooperative learning environments among students (Anjani et al., 2016). Baamboozle educational game is a fascinating option for Game-Based Learning (GBL).

It is an online game specifically designed for education, serving as an interactive learning platform that combines educational elements with games. According to research by Khoiro et al. (2023), the implementation of Baamboozle as a learning medium has shown significant improvements in the interest and learning outcomes of class X students at SMAN 1 Pamarayan, particularly in the field of Sociology. In the Baamboozle game, students actively engage by answering interactive questions related to the material being taught. This game fosters a more active learning environment, enhancing students' understanding of the subject matter (Murti et al., 2023).

The choice of using Baamboozle in the context of the digestive system material is well-founded, considering the abundance of terms within this topic. By utilizing question-based games, Baamboozle facilitates improved memory retention of the material (Wahyuni, 2021). The digestive system poses a complex challenge due to the interrelated terms and concepts it encompasses. However, Baamboozle allows for an interactive and gradual exploration of this subject matter. With the aid of the application's image feature, students gain a clearer understanding of the structure and function of the digestive organs, ultimately solidifying their comprehension of the learned terms. Moreover, Baamboozle offers a wide range of question formats that can be tailored to match the difficulty and complexity of the material. Additionally, the team game feature promotes student discussion and collaboration, enabling a deeper understanding of the digestive process. The interactive and enjoyable nature of Baamboozle not only enhances students' memory recall of terms and concepts but also stimulates their interest and motivation to learn complex digestive system material.

Based on interviews conducted with biology teachers from class XI IPA at HangTuah Belawan High School, it has been revealed that traditional teaching methods have been predominantly employed thus far. The conventional approach involves having students read independently, followed by teacher explanations and subsequent assessments. However, this method proves less effective in generating student interest and comprehension of complex learning materials. Among the topics considered challenging and uninspiring for students is the digestive system. Visualization and simulation are essential for comprehending the intricate processes associated with this subject matter. Based on the problem statement provided, this study aims to develop an innovative and interactive learning instrument that will facilitate student learning activities and help achieve the desired learning outcomes. To accomplish this, game-based learning instruments will be created, utilizing the Baamboozle educational game specifically designed for the digestive system material in class XI. The Baamboozle game will present questions on the digestive system in an interesting and interactive manner, aligning with the learning outcomes for the class.

In addition to the educational games, the learning instruments will include Learning Implementation Plans (RPP), Learner Worksheets (LKPD), and Baamboozle Game Questions. The expected outcome of this research is an improvement in students' learning outcomes and their understanding of the concepts related to the digestive system. The effectiveness of the learning instruments will be assessed through pretests and posttests administered to the students. This study is grounded in Vygotsky's social constructivist theoretical framework, which highlights the importance of social interaction and collaboration in the learning process. In the context of the Baamboozle game, students will have the opportunity to interact and discuss while answering questions, thus building a shared understanding of the concept of the digestive system. The development of this learning instrument aims to produce valid, practical, and effective learning materials that will enhance the learning outcomes of high school students studying the digestive system. Furthermore, it is expected to contribute to the advancement of innovative teaching methods in biology education.

METHOD

The research method is an important component in every scientific research, in this scientific research the type of research is development research or called research and

development (R&D). The development research model used is the four-D (4-D) model developed by S. Thiagarajan, Dorothy S. Semmel, and Melvyn I. This research model has four stages, namely Define, Design, Develop, and Disseminate (Kadir et al., 2018). The following is a detailed description of the stages in the 4-D model (Dewy et al., 2023).

1. The define stage aims to bring up and determine the basic problems faced in learning, so that the development of teaching materials is needed. This process was conducted by interviewing biology teachers with questions covering teaching methods used, challenges in teaching, and the use of technology in learning. Student survey by giving questionnaires on questions covering learning method preferences, understanding of digestive system material, and interest in technology-based learning.
2. The design stage is the initial stage of designing the product to be developed. The products developed are adjusted to the material and learning outcomes. At this stage, the product is adjusted to the material and learning outcomes through the identification of core competencies and basic competencies relevant to the product material. Connecting each part of the product with curriculum standards, the digestive system material is adjusted to KD 3.7 and 4.7 grade XI. Asking experts to verify the suitability of the product to the standard.
3. Stage develop, is the stage to produce development products. The purpose of this stage is to produce the final form of the model and devices developed after going through a revision process based on input from validators and data from development trials. The validator assesses the product using criteria such as the completeness of the learning instrument according to the material, the presentation of the learning instrument according to the KD and Indicators, and the learning instrument has work instructions. Revisions may include correcting factual errors, simplifying language, adding examples, or adjusting the level of difficulty. The researcher analyzes the validator's suggestions and applies revisions systematically to all parts of the product. The revised product was then returned to the validator for final checking, and if necessary additional adjustments were made. After final approval, the product is prepared in its final form with a final check to ensure consistency and quality.
4. Disseminate stage, is the stage to disseminate the research results both to users through socialization, as well as to the general public through seminars and publications in scientific journals.

Data collection techniques in the development of game-based learning instruments through teacher interview sheets; expert validation sheets covering aspects of material, presentation, and construction; student and teacher response questionnaires on the use of learning instruments; pretest and posttest sheets to assess the effectiveness of learning instrument products.

The data analysis technique uses a Likert scale. Likert scale is used to measure the attitudes, opinions, and perceptions of a person or group of people in relation to the product developed. After that, the results of the validation percentage on the scoring interpretation criteria can be grouped according to the Likert scale to draw conclusions on the validity of the instrument. The criteria are listed in the Table 1.

Table 1. Criteria for validity

Interval	Criteria
0% - 20%	Very Invalid
21% - 40%	Invalid
41% - 60%	Moderately Valid
61% - 80%	Valid
81% - 100%	Very Valid

Source (Ayu Fitriyani et al, 2020)

Analysis of the practicality of the instrument using student and teacher response tests, researchers measure by giving a questionnaire to the teacher and to each student, then the questionnaire is calculated for each question item using the following formula:

$$P = \frac{F}{N} \times 100\%$$

Description:

P = percentage number

F = score obtained

N = maximum score

The percentage results from the teacher and student response data are then used to determine the practicality of the developed instrument. The criteria are as follows:

Table 2. Practicality Criteria

Interval	Criteria
0% - 20%	Not Very Practical
21% - 40%	Not Practical
41% - 60%	Moderately Practical
61% - 80%	Practical
81% - 100%	Very Practical

Source (Ayu Fitriyani et al, 2020)

Analysis of the effectiveness of learning instruments is carried out after obtaining the results of pretest and posttest scores, researchers analyze the scores obtained. Analysis using the normality gain test. The formula used to calculate the normality of the gain (A'yunul Husna et al., 2023):

$$N - Gain = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum possible score} - \text{pretest score}}$$

Table 3. Normalized Gain Criteria

Interval	Criteria
$0,70 \leq g \leq 100$	High
$0,30 \leq g < 0,70$	Medium
$0,00 < g < 0,30$	Low
$g = 0,00$	Improvement
$-1,00 \leq g < 0,00$	There is a decrease

Table 4. Effectiveness Criteria

Interval	Criteria
76-100	Very effective
51-75	effective
26-50	Less effective
0-25	Not effective

Source: (Riduwan et al, 2013)

The questions that will be applied to the Baamboozle game are first tested for validity. The maximum score on each question is 3 and is given a score (0, 1, 2, 3) 0 if the answer to the question is wrong, 1 if the answer is not good, 2 if the answer is good, and 3 if the answer is very good. The questions will be tested for validity and reliability. For item validity, it is calculated using the Pearson product moment correlation formula (Hafni Sahir, 2021):

$$r_{xy} = \frac{N \sum xy - (\sum x)(\sum y)}{\sqrt{\{N \sum X^2 - (\sum X)^2\} \{N \sum y^2 - (\sum y)^2\}}}$$

This reliability test uses the Cronbach Alpha formula (Yusup, 2018) as follows:

$$r_i = \frac{k}{(k-1)} \left\{ 1 - \frac{\sum s_i^2}{s_t^2} \right\}$$

Table 5. Criteria for Reliability Coefficient

Interval	Criteria
0,80 – 1,00	Very Reliable
0,60 – 0,80	Reliable
0,40 – 0,60	Quite Reliable
0,20 – 0,40	Less Reliable
-1,00 – 0,20	Not Reliable

Source: (Arikunto, 2011)

RESULTS AND DISCUSSION

This development research produces Game Based Learning-based learning instruments that contain class XI biology material, namely the digestive system with the help of Baamboozle educational games. The learning instrument developed consists of a Learning Implementation Plan (RPP), Learner Worksheet (LKPD), Baamboozle Game Questions. The development research model used is the four-D (4-D) model developed by S. Thiagarajan, Dorothy S. Semmel, and Melvyn I. Thiagarajan. This research model has four stages, namely Define, Design, Develop, and Disseminate (Kadir et al., 2018).

Define stage

This game-based learning instrument with the help of bamboozle game was developed based on the problems found when conducting observations and interviews with biology teachers at HangTuah Belawan private high school. The results of the interview found that the learning methods that have been applied tend to be conventional. The teacher stated that learning is done by giving students the opportunity to read first, then the teacher explains, and finally gives a quiz. This method is less effective in increasing student interest and understanding of complex digestive system material. There is a gap between the currently applied learning methods and the needs of students to understand the digestive system material effectively. This gap is measured by the teacher's explanation that on average 60% of students have not reached the minimum completion criteria (KKM). The use of conventional methods is less able to motivate students and create an interactive learning environment. The identified student problems, such as lack of confidence and jealousy among students, indicate the need for a more inclusive learning approach that actively involves all students. This is in line with the opinion of Anjani et al (2016) who stated that game-based learning can affect learners' motivation and make them feel more excited and challenged.

The development of learning instruments based on Game Based Learning is expected to overcome the existing problems. This approach has the potential to increase the active participation of all students, visualize complex concepts in the digestive system, and create a more enjoyable and inclusive learning environment. This is in accordance with the findings of Made et al. (2023) who stated that Game Based Learning is a learning approach that involves students actively in the learning process to improve their knowledge and skills.

Design Stage

The initial design of game-based learning instruments includes:

- 1) Learning Implementation Plan (RPP); designed by integrating the use of Baamboozle in learning the digestive system. This lesson plan includes clear learning steps, time allocation, assessment methods. The learning syntax is adjusted to the game-based learning syntax, namely choosing games according to the topic, explaining concepts, agreeing on rules, playing games, summarizing knowledge, and reflecting.
- 2) Learner Worksheet (LKPD); Designed to support student activities during and after playing the Baamboozle game. LKPD is designed in accordance with the learning syntax and is equipped with basic competencies, learning indicators, learning objectives, work instructions, theoretical basis, Barcode so that students can more easily access baamboozle games and learning videos through scanning barcodes contained in LKPD.



Figure 1. Cover & content view of LKPD

- 3) Baamboozle Game Content; The questions and game content are designed according to the learning outcomes of the digestive system in grade XI. This content covers various aspects of the digestive system, including the organs of digestion, mechanical and chemical digestion processes, and disorders of the digestive system. The baamboozle game questions are taken from school biology textbooks and learning videos, then adjusted to the indicators and learning outcomes. Here's a look at the baamboozle game:

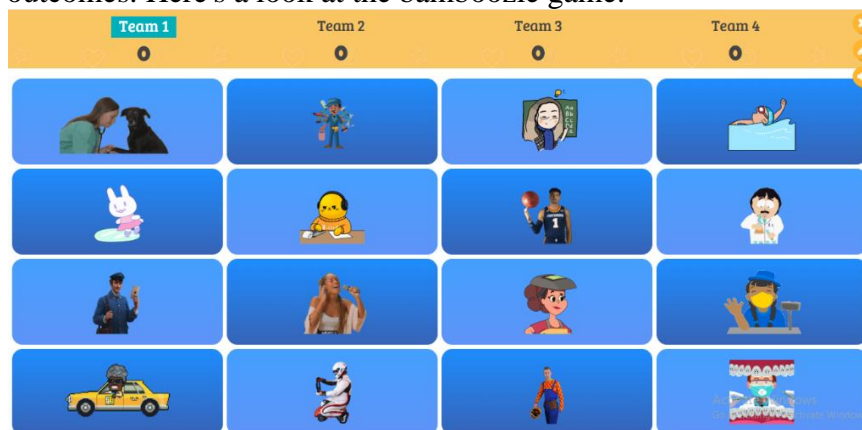


Figure 2. Game page for students to select one of the views on the jobs theme

Develop Stage

Learning Instrument Validity

Validation of learning instruments was validated by two learning instrument experts. The learning instruments developed were considered very valid by the experts, with a percentage of validity from the first learning instrument expert 100% and the second learning instrument expert 87%. This shows that the learning instrument based on Game Based Learning assisted by Baamboozle game has met the standards of material, construction, and presentation that are valid and feasible. In line with research (Shellyna et al., 2023) shows that the development of

game-based learning media is said to be valid with the acquisition of material and media validation scores of 78.86% and 88.94% with an average percentage of both of 83.9%. Some suggestions for improvement from experts have been followed up, such as from the first learning instrument expert, the video inserted in the LKPD needs to be adjusted to the scope of biology learning at the high school level which includes the basic competencies and achievement indicators of the digestive system in class XI. Suggestions for improvement from the second learning instrument expert, the material must be in accordance with the concept map of the digestive system and the learning video is more interesting in order to increase student interest in learning.

Table 6. Results of Learning Instrument Expert Validation Analysis I

Aspect	Score Obtained	Maximum Score	Percentage (%)	Criteria
Material	20	20	100%	Very Valid
Construction	16	16	100%	Very Valid
Presentation	12	12	100%	Very Valid
Total		48		
Maximum Score		48		
Percentage		100%		
Criteria		Very Valid		

Table 7. Results of Learning Instrument Expert Validation Analysis II

Aspect	Score Obtained	Maximum Score	Percentage (%)	Criteria
Material	20	24	83%	Very Valid
Construction	20	24	83%	Very Valid
Presentation	12	12	100%	Very Valid
Total		52		
Maximum Score		60		
Percentage		87%		
Criteria		Very Valid		

Practicality of Learning Instrument

The results of the response questionnaire show that the learning instrument is considered very practical by the HangTuh High School biology teacher with a score of 45 and a maximum score of 48, obtaining a percentage of 94% in the very practical category. Students consisted of 31 students with a score of 1268 and a maximum score of 1488 obtained a percentage of 85% in the very practical category. Teachers considered that this instrument made it easier for them to deliver digestive system material and increase student enthusiasm. Students felt that learning became more interesting and helped them understand complex concepts in a fun way. Some students commented, "learning through games is very interesting and makes us eager to learn and the explanation in the learning video is very clear and easy to understand".

Table 8. Results of Percentage Analysis of Student Response

Number of Students	Score Obtained	Maximum Score	Percentage (%)	Criteria
31 Students	1268	1488	85%	Very Practical

Table 9. Results of Percentage Analysis of Teacher Response

Aspect	Score Obtained	Maximum Score	Percentage (%)	Criteria
Material	20	20	100	Very Practical
Construction	14	16	87	Very Practical
Presentation	11	12	92	Very Practical
Total		45		
Maximum Score		48		
Percentage Criteria		94%		Very Practical

Effectiveness of Learning Instruments

To see the effectiveness of game-based learning instruments, students were given a pretest and posttest of 30 multiple choice questions on digestive system material. The pretest is given before the learning begins, the learning process is carried out by applying game-based learning instruments assisted by baamboozle games. The posttest will be given after the learning is completed. From the results of the normality gain analysis, the increase in the average score from pretest 57.5 to posttest 80 shows the effectiveness of the learning instrument. The N-Gain score of 0.53 indicates a moderate increase in learning outcomes. The effectiveness percentage of 53% indicates that the learning instrument is effective in improving student learning outcomes on digestive system material. This is in line with the research of Khoiro et al. (2023) who found an increase in student learning outcomes using Baamboozle in Sociology learning. However, the implementation of this learning also faces some challenges and limitations, such as students with different cognitive levels, the level of student engagement which mostly shows active participation but there are some students who tend to be passive, and unstable internet connection.

Table 10. Gain Normality Analysis Results

Pretest	Posttest	N-Gain	Percentage (%)	Criteria
57.5	80	0.533	53%	Effective

Previous research by (Prista et al., 2023) his research produced teaching material products in the form of E-LKPD based on Game Based Learning assisted by Live Worksheets on valid, effective, and practical mapping material in the validity test acquisition which was 90% of the assessment of design expert validators and material experts. The acquisition of the practicality level test is 68% of the student and teacher assessments. The effectiveness test is 81% which is taken from student learning outcomes. Research by (Lamada & Putriani, 2021) produced an instrument in the form of interactive multimedia based on game-based learning in science subjects that met the feasibility criteria of "very good" obtained from 3 trials ranging from one to one trials with a final result of 89, small group trials with a final result of 90.6, and large group trials with a final result of 92.1, so that the average of the three trials conducted, namely 90.5, was included in the very good category. The research conducted by the two researchers above shows that the development of game-based learning instruments meets the requirements of valid, practical, and effective. This shows that game-based learning instruments can be used in supporting the success of learning.

Question Item Analysis

After the questions were validated by the item experts and before the questions were used in the baamboozle game, they were first tested by IPA II class students with a total of 10 students. The number of questions tested was 44 essay questions. This test is carried out to obtain a valid and reliable instrument. The results of testing the validity of questions that are

declared valid if they have rcount greater than rtable. From the results of the item validity test, 38 valid questions were obtained and 6 invalid questions. Questions that are declared valid will be used in the baamboozle game and used for the next test. Meanwhile, questions that are declared invalid will be discarded and not used. This is based on the statement (Marthunis et al., 2020) that question items that are declared invalid should be corrected and valid questions can be reused. The results of the question reliability test obtained an r value of 0,966 with a very reliable instrument category. According to (Sudarwan & Retnawati, 2015) reliability is related to the consistency of the assessment results. Reliable assessment allows reliable comparisons or ensures consistency and trustworthiness of the instrument.

Table 11. Validity and Reliability Results

Validity	Number of valid	Number of invalid
	38 questions	6 questions
Reliability	0.9666	

At this stage, the distribution of the final product produced which has met the criteria is feasible for use to biology teachers at the research site, namely HangTuah Belawan Private High School.

CONCLUSION

The Four-D development model (Define, Design, Develop, Disseminate) was successfully implemented in the development of Game Based Learning instruments for teaching the digestive system using Baamboozle. The developed instruments, which include lesson plans, LKPD, and Baamboozle game content in the form of questions, have been proven to be valid, practical, and effective. The first expert's evaluation of the instrument's validity yielded a score of 100%, while the second expert's evaluation resulted in a score of 87%, both falling within the highly valid category. The practicality of the instruments was demonstrated by positive feedback from teachers (94%) and students (85%), both indicating a high level of practicality. Furthermore, the effectiveness of the instruments was evidenced by an increase in student learning outcomes, as indicated by an N-Gain score of 0.53 (falling within the medium category) and an effectiveness rate of 53% in the effective category. This research underscores the effectiveness of integrating technology and a game-based approach in biology education to address students' difficulties in comprehending the digestive system.

RECOMMENDATION

For future research, it is advisable to further develop the Baamboozle educational game to encompass additional biology topics, thereby augmenting the potential of game-based learning. Implementation presents certain challenges, including the requirement of a reliable internet connection and the need for increased preparation time for educators. Nevertheless, these obstacles can be addressed by ensuring seamless internet access within the school environment and by empowering teachers to create game content for three sessions, thereby reducing their preparation time.

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