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Developing Puzzle Based Case Study to Improve Cognitive Learning Outcomes of High School Students

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Abstract

The aim of this research was to develop Puzzle Based Case Study (PBCS) media that is valid, practical, and effective in enhancing students' cognitive learning outcomes on the topic of the respiratory system. PBCS is a form of media that combines elements of a puzzle game with case study questions. The research followed the ADDIE development model, which includes the stages of Analyze, Design, Develop, Implement, and Evaluate. The validity of the media was determined through input from three validators: media experts, material experts, and educational practitioners. The practicality of the media was assessed through questionnaires administered to students and teachers. To measure the effectiveness of the media in improving cognitive learning outcomes, pretest and posttest assessments were conducted, followed by an analysis of the n-gain. The results of the material validation process showed a 100% agreement, while the media validation process also achieved a 100% agreement. The validation process involving educational practitioners resulted in a 98.6% agreement. The practicality of the media was rated as 95.6% (indicating high practicality). The effectiveness of the media, as measured by the N-Gain value of 0.62, met the criterion for effectiveness at 62% (moderately effective). These findings demonstrate that PBCS is a valid, practical, and effective tool for enhancing students' cognitive learning outcomes in the study of the respiratory system. Based on these results, PBCS can serve as a valuable resource for the development of other game-based media in various educational disciplines.

Keywords: Puzzle Based Case Study; Cognitive Learning Outcomes; Respiratory system

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INTRODUCTION

The learning process is defined as the transformation of knowledge from teachers to students. It involves key elements like learning objectives, resource development, and implementation of teaching strategies (Munna & Kalam, 2021). The success of learning is determined by students' attainment of good cognitive learning outcomes (Rafiola et al., 2020). Cognitive learning outcomes refer to the knowledge acquired after the learning process (Tung & Alissa, 2021). High cognitive learning outcomes are crucial as they serve as a measure of learning success (Peng et al., 2021).

Biology learning focuses on the study of living organisms, including humans and plants, and how they interact with the environment (Syam & Sujarwo, 2023). In biology, students are expected to possess strong problem-solving abilities, hence making high cognitive learning outcomes an important indicator of their competency (Ramadhan et al., 2017). However, research suggests that students, particularly in biology, often achieve low cognitive learning scores that fall below the established standards (Harefa et al., 2023; Rahma & Ristiono, 2021).

There are several factors contributing to low cognitive learning outcomes in biology. These include lack of student interest in learning (Dahliani et al., 2020), students being

positioned as passive listeners (Hermawan et al., 2020), inappropriate teaching techniques, and insufficient time allocated for teaching the material (Ndayambaje et al., 2021). Additionally, students perceive biology material as challenging to comprehend (Çimer, 2012; England et al., 2017). The human respiratory system is identified as one of the biology topics that students find particularly difficult to understand (Bintley et al., 2019). This observation is supported by a preliminary study conducted at Surya Buana Senior High School, which revealed that 87.5% of students agreed that the human respiratory system material contained complex explanations, 62.5% of students found it challenging to learn about the human respiratory system, and 75% of students often struggled to analyze problems related to the human respiratory system.Several factors contribute to the difficulty in comprehending the material related to the human respiratory system. Nur and Ozkan (2017) emphasized that this challenge stems from the diverse concepts regarding structure, function, and mechanisms that students must grasp. Colthorpe et al. (2018) further noted additional reasons for the difficulty, including students feeling unfamiliar with the terminology associated with the respiratory system, the complexity of the material, and the intricate processes involved in understanding it. Tapia et al. (2019) found that students often struggle to explain individual mechanisms within the respiratory system due to their similarities and resulting confusion. Moreover, the limited opportunities for applying their understanding to problem-solving hinder students' ability to analyze the underlying processes (Carvalho & West, 2011). Additionally, the lack of effective learning resources exacerbates the challenges faced by students (Sari et al., 2020; Akbar & Mukminan, 2019).

Interviews conducted with teachers at Surya Buana Senior High School Malang revealed suboptimal cognitive learning outcomes among students in their previous lessons on the human respiratory system. Remarkably, only approximately 50% of students achieved the school's minimum passing grade of 75. The choice of learning media during instruction can significantly impact students' cognitive learning outcomes (Kareem, 2018; Topano et al., 2021). Teachers at Surya Buana Senior High School Malang expressed that students prefer game-based learning media; however, the utilization of game media to deliver the topic of the human respiratory system has not yet been implemented.The low cognitive learning outcomes among students, particularly in relation to the human respiratory system, present a significant challenge that needs to be addressed. Introducing game-based media as a solution has shown promising results in improving students' cognitive learning outcomes (Cheng & Annetta, 2012; Firdaus et al., 2018; Yu et al., 2021). According to Edgar Dale's cone of experience, media that offer opportunities for students to engage in role-playing, simulation, and hands-on activities can enhance their memory retention of the learning material by up to 90% (Pietroni, 2019).

One effective game-based learning media that actively engages students is Puzzle Based Case Study (PBCS). This learning approach is a modified version of the traditional puzzle game, where each puzzle piece consists of two sides: the front side presents alternative answers to a case study question pertaining to the human respiratory system, while the back side contains pieces of an image. The aim of the game is for students to successfully answer all the cases and assemble the puzzle pieces correctly, forming a complete image at the back.

PBCS strategically incorporates real-life cases that students commonly encounter in their communities, generating their interest in solving these cases (Fauzi et al., 2023). To minimize confusion, the question cards in PBCS are designed using straightforward language that students can easily understand. The utilization of PBCS in collaborative group settings enables students to discuss the mechanisms underlying the case presented on the question cards, facilitating the identification of the most appropriate answers. Active student involvement in the PBCS game has been shown to enhance students' comprehension of respiratory system concepts (Lubis et al., 2019). Solving PBCS requires more than mere memorization; students need to exchange ideas within their groups to arrive at solutions (Zirawaga et al., 2017).

The inherent excitement and challenge of puzzle games have been recognized as effective tools in enhancing learning outcomes, particularly in the field of biology (Johnson, 2019).

Research supports the notion that puzzle game media improves student learning outcomes (Zb et al., 2022; Marlina et al., 2021; Nirmal et al., 2020). Engaging with puzzles allows students to acquire new knowledge while simultaneously testing their problem-solving skills and building their confidence (Rodenbaugh et al., 2015). Integrating case study questions into PBCS facilitates deep thinking and promotes a better understanding of the material (Allen & Toth-Cohen, 2019; Bonney, 2015). Case study questions refer to inquiries that involve concrete scenarios or problems, prompting students to think critically in order to grasp key concepts (Mahdi et al., 2020).Previous research has extensively examined the use of puzzle games in learning (Bawazeer et al., 2022; Mshayisa, 2020; Rodenbaugh et al., 2015). However, there is still a scarcity of research that utilizes case studies in puzzle media. Irmayanti and Amalia (2022) conducted a study on the use of puzzle games in the classification of living things, specifically utilizing a crossword puzzle where students had to answer questions in designated boxes. This approach emphasized the memorization process, which is in contrast to current biology education that emphasizes critical thinking and comprehension (Rahmah, 2022).

No studies have been found that investigate the use of puzzles to enhance students' cognitive learning outcomes specifically in the context of the human respiratory system. A preliminary study revealed low cognitive learning outcomes among students in this subject area. Furthermore, 87.5% of students expressed satisfaction and agreement in incorporating Puzzle-Based Case Study (PBCS) media into their learning experiences. Consequently, the development of PBCS media was pursued to enhance student learning outcomes in the field of human respiratory system. The active involvement of students in the application of PBCS is anticipated to enhance the quality of learning and consequently improve student learning outcomes. The hypothesis of this research is that PBCS can enhance students' cognitive learning outcomes, specifically in the realm of human respiratory system education. This research aims to contribute to the body of knowledge on captivating learning media and address challenges encountered in biology education.

METHOD

This study is an application of the ADDIE development model, as proposed by Branch (2010). The selection of this model was based on its simplicity, ease of comprehension, and well-defined structure and sequence, as highlighted by Usta and Güntepe (2017). The ADDIE development model comprises five distinct steps: analysis, design, development, implementation, and evaluation (see Figure 1).

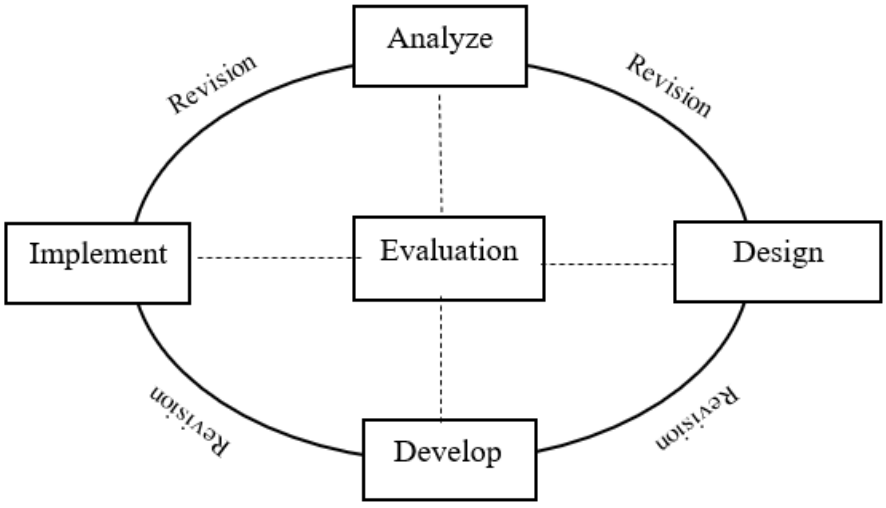


Figure 1. The ADDIE development procedure

The Analyze stage aimed to identify gaps in biology learning, determine goals, determine targets, and determine how to deliver the developed products. This stage was carried out by distributing instruments, such as a gap analysis questionnaire to students and interview texts to

teachers at Surya Buana Senior High School. The questionnaires were given to eight students in Class XII MIPA. The questionnaire included questions about students' perception of biology learning and analyzed their difficulties in biology topics. The interview questions focused on how the teacher taught biology and assessed students' ability to understand the material.

The Design stage involved designing the necessary content to achieve the objectives and determining the assessment strategy. During this stage, we prepared the storyboard for the Puzzle Based Case Study (PBCS) media, learning tools, validation instruments, and pretest and posttest questions. The PBCS media storyboard depicted how the game would be played, identified the media components and their use, and established the rules of the game. The media assessment involved evaluating the validity, practicality, and effectiveness of the media in improving students' cognitive learning outcomes.

The Develop stage aimed to bring to life the previously designed product or content and identify areas that required improvement. In this stage, we used the Canva application to design the PBCS media. We then proceeded with the validation and practical testing of the PBCS media. The validation process included a validation questionnaire that was filled out by expert validators in the field of biology education. The results of the validation were compiled, converted into percentages, and categorized according to predetermined validity criteria. The suggestions and input provided by the validators served as a reference for improving the PBCS media. After incorporating the revisions, the media underwent another round of validation until it was deemed feasible. The practicality testing of the media took place after a trial in Class XII Science, where the students had covered the topic of the human respiratory system. The practicality test involved a questionnaire that gathered student and teacher responses to assess their experience with the PBCS media. The resulting media was then categorized based on the validity and practicality criteria outlined by Aka et al. (2018) and presented in Table 1.

Tabel 1. Criteria for media validity and practicality

Percentage (%)	Criteria
X = 100	Very valid/practical, can be used without revision
80 ≤ X < 100	Valid/practical, can be used with revision
60 ≤ X < 80	Less valid/practical, can be used with revision
40 ≤ X < 60	Not valid/practical, not recommended for use
20 ≤ X < 40	Very invalid/practical, not used

The implementation stage aimed to demonstrate the efficacy of the product in enhancing students' cognitive learning outcomes. The implementation took place in class XI Science of Surya Buana Senior High School during the Academic Year 2023/2024, involving a total of 8 students. The integration of PBCS media with the Teams Games Tournament (TGT) learning model was carried out. TGT comprised five stages of activities, namely class presentation, team or group formation, games, tournaments, and team recognition. The use of PBCS media specifically occurred in the third stage, which is the games stage. To assess the effectiveness of the media in improving cognitive learning outcomes, pretest and posttest questions were employed as assessment instruments. The pretest and posttest scores were analyzed using formula (1) according to Akbar's (2013) guidance.

$$P = \frac{Tse}{Tsh} \text{ x } 100 \qquad (1)$$

Description:

P : Grade
Tse : Total empirical score
Tsh : Total expect score

The evaluation stage is conducted at each step of the ADDIE model in order to assess the quality of the product and instructional process. The effectiveness of the media on students' cognitive learning outcomes was determined through pretest and posttest scores. Shapiro-Wilk

normality tests were performed on the pretest and posttest scores to check for normal distribution of the data. If the data was found to be normally distributed, a paired sample T-test was carried out. The p-value was compared to α (α = 0.05) to determine the significance of the difference in the variables being tested. If the p-value < 0.05, H1 was accepted, indicating a significant difference from the treatment. Conversely, if the p-value > 0.05, H1 was rejected, indicating no significant difference from the treatment. If the data was not normally distributed, the Wilcoxon signed test was conducted. The decision-making criteria for the Wilcoxon test were as follows: if Asym.Sig (Z-tailed) < 0.05, H1 was accepted, indicating a significant difference from the treatment. On the other hand, if Asym.Sig (Z-tailed) > 0.05, H1 was rejected, indicating no significant difference from the treatment. The findings of the statistical analysis of the pretest and posttest results are presented in Figure 2.

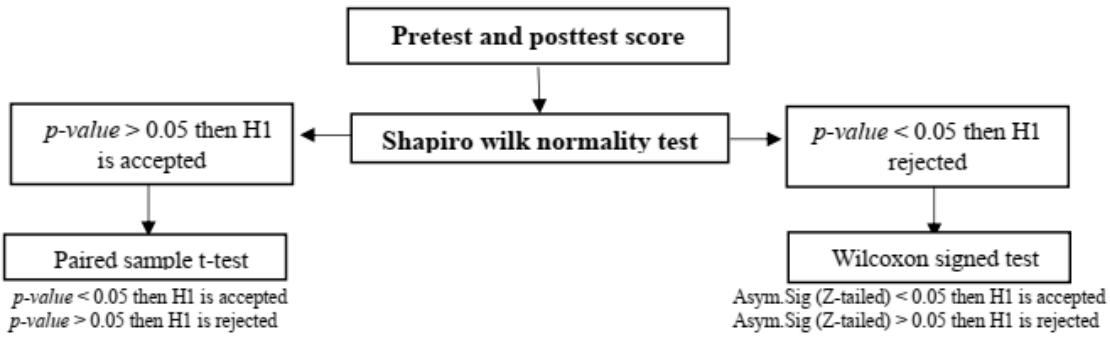


Figure 2. Flowchart of statistical tests

To determine the efficacy of PBCS media in enhancing students' cognitive learning outcomes, the study conducted the Normalized Gain test (N-gain). Formula (2), based on Hake's work from 1998, was employed to analyze the extent of improvement between pretest and posttest scores.

$$g = \frac{Sf - Si}{100 - Si} \quad (2)$$

Description:

q : Gain normalized score
Sf : Posttest score
Si : Pretest score

After obtaining the N-gain score, it was subsequently classified according to the improvement criteria and effectiveness criteria outlined by Hake (1998). These criteria are presented in Table 2 and Table 3.

Table 2. N-Gain Criteria

Skor N-Gain	Criteria
$g < 0{,}7$	High
$0{,}7 \leq g \leq 0{,}3$	Medium
$g < 0{,}3$	Low

Table 3. N-Gain effectiveness criteria

Persentase (%)	Criteria
< 40	Not effective
40 – 55	Less effective
56 – 75	Moderately effective
> 76	Effective

RESULTS AND DISCUSSION

The results of the gap analysis conducted on biology learning at SMA Surya Buana revealed that some students have not met the Minimum Completion Criteria (KKM) of 75 for the topic of the human respiratory system. Only 50% of students were able to reach the KKM. Interviews conducted with biology teachers at SMA Surya Buana Malang indicated that game-based media is rarely used in teaching the human respiratory system. Furthermore, preliminary studies conducted with students supported the development of Puzzle Based Case Study (PBCS) media, as 87.5% of students expressed interest in learning about the human respiratory system using game-based media, and 87.5% of students agreed that a puzzle game media should be developed for biology learning.

The development of the PBCS media resulted in a set of games that are designed to achieve specific learning objectives. These learning objectives aim to enable students to properly analyze the relationship between the structure, function, and disorders of the human respiratory system. The game set comprises various components, including question cards, answer cards, puzzle boards, teacher's guide books, and student guide brochures.

The Development Results and Validity of the Puzzle Based Case Study (PBCS) Media

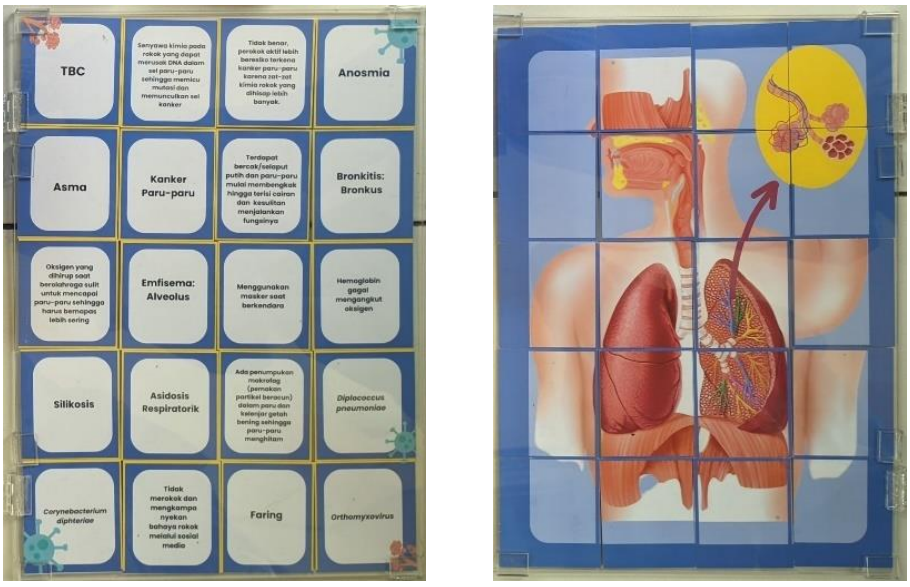
The PBCS is played in groups consisting of 5-6 students. Group organization during the learning process motivates students to actively participate and enhances student performance (Harding, 2018). This media consists of several components, such as question cards, answer cards, puzzle boards, teacher's guide books, and student guide brochures. The question cards consist of 20 case study questions related to diseases of the human respiratory system. These cards have dimensions of 5.9 x 8.5 cm and are colored blue (Figure 3a). The use of case studies on the question cards is based on the contextual nature of the human respiratory system topic (Snapir et al., 2017). The contextual cases presented on the question cards include lung cancer, the high prevalence of cigarette smoking, and COVID-19, among others. These cases help students connect their knowledge with real-life contexts and apply that knowledge (Hasruddin et al., 2015). Moreover, the inclusion of diverse cases on the question cards facilitates students' critical thinking process, thereby enhancing their learning outcomes (Tuaputty et al., 2021).

(a) (b) (c)

Figure 3. (a) Question card; (b) Frontside answer card; (c) Backside of answer card

The answer cards consist of 40 cards, with 20 providing correct answers and 20 providing incorrect answers to the case study questions. Each answer card has two sides: the front (Figure 3b) displays the answers, while the back (Figure 3c) contains puzzle pieces that form the anatomical structure of the human respiratory system. The image on the back of the answer card serves to pique students' interest in the PBCS media and helps them develop a better understanding of the organs comprising the human respiratory system. The inclusion of wrong answers on the answer cards challenges students to think critically and determine the correct answer (Ipin, 2018). The development of good critical thinking skills has a positive impact on students' learning outcomes (Fitriani et al., 2020).

Another component of the PBCS media is the puzzle board, which is made of transparent acrylic and measures 26 x 36 cm. The use of acrylic for the puzzle board allows the image on the back of the answer card to be clearly visible when the cards are arranged on the board. Figure 4 illustrates the puzzle boards used in the PBCS media.



(a) (b)

Figure 4. (a) Frontside puzzle board; (b) Backside puzzle board

The teacher's guidebook includes the Learning Outcomes in Phase F, learning objectives to be accomplished, instructions for the PBCS game, a list of questions, and the answer key (Figure 5).

Figure 5. Teacher's guidebook

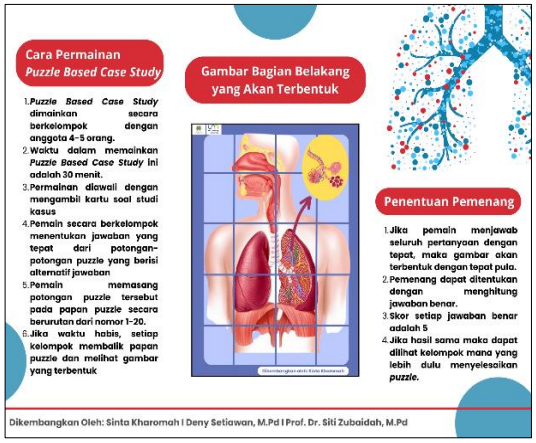


Figure 6. Students guide brochure

The teacher's guidebook comprises 13 pages, with a book size of 20 x 14 cm. On the other hand, the student guide brochure provides a concise explanation of PBCS, learning objectives, game instructions, and accompanying images that are formed when all the answer

cards are arranged (Figure 6). In the development of educational games, a game manual is essential to ensure that both students and teachers comprehend how the game functions and its rules (Winarni et al., 2020).

The PBCS media was subsequently subjected to validation by experts in the field, including material experts, media experts, and educational practitioners. Material validation refers to the evaluation of the tool's effectiveness in assessing the variables or characteristics that need to be measured (McCarthy et al., 2023). The outcomes of the material validation process are presented in Table 4.

Table 4. Validation result by material experts

No	Assessment aspect	Percentage (%)	Criteria
1.	Content eligibility	100.00	Very valid
2.	Presentation feasibility	100.00	Very valid
3.	Language	100.00	Very valid
4.	Usage	100.00	Very valid
	Average	**100.00**	**Very valid**

Table 4 presented the findings indicating that the material validity on the PBCS media exhibited a 100% score, meeting the criteria for validity. It is crucial for educational resources to possess accurate and valid content to prevent any misconceptions among students when utilizing such media (Nazar et al., 2020). Some revisions made by material experts focused on improving the clarity of language in the question cards, aiming to facilitate better understanding of the intended meaning by students. The validation process in this study involved thorough examination to eliminate any content errors in the media. Additionally, the media underwent validation by experts in the field. The outcomes of the media validation by these experts are presented in Table 5.

Table 5. Validation result by media experts

No	Assesment aspect	Percentage (%)	Criteria
1.	Graphics	100.00	Very valid
2.	Language	100.00	Very valid
3.	Usage	100.00	Very valid
	Average	**100.00**	**very valid**

Based on Table 5, the PBCS media demonstrated 100% validity based on highly valid criteria. The media expert validator deemed the PBCS to be overall effective and engaging. However, there were some graphics that did not align with the presented material. Specifically, there was an image of hemoglobin on the answer card that served no functional purpose and was purely decorative. Therefore, the validator recommended replacing this image with one that better reflected the content on the respiratory system. Consequently, the hemoglobin image was substituted with images of viruses and alveoli. These images were considered more appropriate in representing the respiratory system organs, as viruses are associated with various respiratory diseases. The media validation process continued until the media was deemed highly feasible and valid for use.

Additionally, the validator proposed including instructions for students on how to use the media in the form of brochures. Furthermore, improvements were suggested for the puzzle board to prevent the answer cards from changing position when arranged. Initially, the instructions for media usage were only provided to the teacher, assuming that the teacher would then explain the instructions to the students. However, it was recognized that students also needed direct access to the instructions in order to avoid confusion. As for the puzzle board, it initially consisted of two acrylic sheets that could be opened and closed, similar to a laptop. This design flaw caused the answer cards to easily shift position, resulting in a disorganized

back image. To address this issue, enhancements were made to the puzzle board by incorporating an acrylic locking device to prevent the answer cards from moving. All recommendations from the media validators were implemented to ensure the proper functionality of the PBCS media. The final validation test was conducted by educational practitioners, specifically biology teachers at SMA Surya Buana Malang. The results of the validation test conducted by the biology teachers are presented in Table 6.

Table 6. Validation result by educational practitioners

No	Assesment aspect	Percentage (%)	Criteria
1.	Material aspect	97.20	valid
2.	Media aspect	100.00	Very valid
	Average	**98.6%**	**valid**

Table 6 demonstrates that the media's validity among educational practitioners was 98.6%, placing it within the valid category. The advice provided by these practitioners emphasized the need for the media to use communicative, effective, and efficient language in its content. Validators offered suggestions to enhance the usability of the PBCS media.

Following the completion of the entire validation process, a small group trial was conducted to assess the media's practicality. The practicality assessment involved administering questionnaires to students and teachers, which focused on gauging their opinions on the media's ease of use, attractiveness, and usefulness. The small group trial involved a total of 8 students from class XII SMA Surya Buana. Table 7 presents the results of the practicality testing of the media.

Table 7. Results of PBCS Media Practicality Test

No	Respondent	Percentage (%)	Criteria
1.	*Small Group Trial*	93.20	Practical
2.	Teacher response	98.00	Practical
	Average	**95. 60**	**Practical**

Based on Table 7, the practicality of PBCS media was 95.6%, indicating a positive response and inclusion in the practical category. The validation test and practicality test results further confirm the validity and practicality of the PBCS media, making it suitable for implementation.

Puzle Based Case Study to Improve Cognitive Learning Outcomes

The implementation took place in class XI IPA SMA Surya Buana Malang, involving a total of 8 students. The PBCS media was implemented using the TGT model, which includes five syntax activities: class presentation, team or group work, games, tournaments, and team recognition. PBCS was introduced to students during the third activity, the game. The media was played in groups of 4-5 members, with each member assuming different roles such as question reader, puzzle builder, and answer seeker. However, group discussions were still conducted collectively.

The development of PBCS media aimed to enhance students' cognitive learning outcomes. Prior to the implementation, students were given pretest questions to assess their initial ability level. A posttest was administered after the implementation of PBCS media. The scores from both the pretest and posttest were analyzed to evaluate the effectiveness of the media in improving students' cognitive learning outcomes. The average results of the pretest and posttest scores are presented in Figure 4.

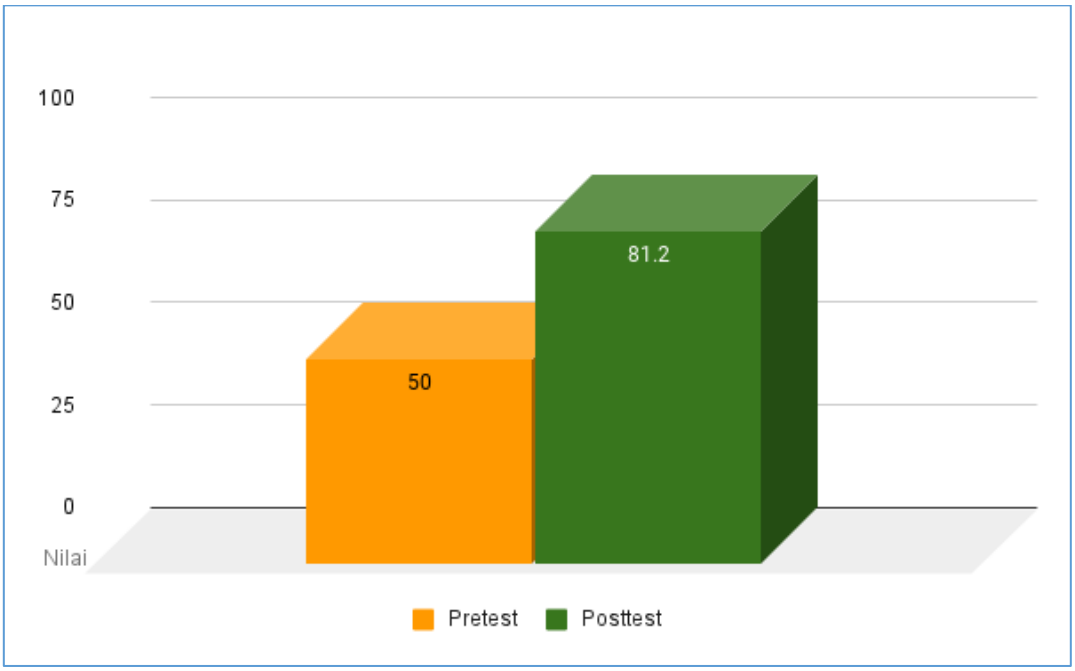


Figure 2. Average of prestest and postets scores

Based on Figure 4, the disparity between the average scores of students' cognitive learning outcomes before and after the intervention becomes apparent. Subsequently, descriptive tests were conducted on the pretest and posttest scores. The outcomes of these statistical analyses are presented in Table 8.

Table 8. Descriptive statistical test of students' cognitive learning outcomes

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest	8	30	60	50	3.27
Posttest	8	80	90	81.2	3.5
Valid N (listwise)	8				

Based on Table 8, it is evident that the pretest of students' cognitive learning outcomes has a standard deviation of 3.27 and an average of 50. Similarly, the posttest of students' cognitive learning outcomes has a standard deviation of 3.5 and an average of 81.2. The data was subsequently subjected to a normality test. The results of the Shapiro-Wilk normality test reveal that the significance value for the student pretests is 0.10 (<0.05), implying that the data is not normally distributed. Likewise, the significance value for the students' posttest is 0.00 (<0.05), indicating that the data is also not normally distributed. Due to the non-normal distribution of the data, the Wilcoxon Test was employed to examine the difference between the pretest and posttest results. The outcomes of the Wilcoxon Test are presented in Table 9.

Table 9. Wilcoxon Test Results pretest and posttest cognitive learning outcomes

	Cognitive learning outcomes
Z	-2.63
Asymp.Sig (Z-tailed)	.008

Table 9 indicated that the pretest and posttest yielded a significance value of 0.008 (0.008 < 0.05), thereby accepting H1 and demonstrating a significant disparity in students' cognitive learning outcomes between the pretest and posttest. Subsequently, the N-Gain test was administered to assess the efficacy of PBCS media in enhancing cognitive learning outcomes by comparing the pretest and posttest scores of students. The findings from the N-Gain test are presented in Table 10.

Tabel 10. N-Gain Test Results Cognitive learning outcomes

	N	Minimum	Maximum	Mean	Std. Deviation
Skor N-Gain	8	0.5	0.75	0.62	0.07
N-Gain (%)	8	50	75	62	7.76
Valid N (listwise)	8				

Based on Table 10, the average N-gain score was 0.62, and the N-Gain percentage was 62%, falling within the moderate and quite effective range. These findings demonstrate that the utilization of PBCS (Problem-Based Case Study) media is highly effective in enhancing students' cognitive learning outcomes. Before the implementation of PBCS media, students had an average cognitive score of only 50, indicating that they were unable to meet the Minimum Passing Grade (KKM) for Biology at SMA Surya Buana. However, after the introduction of PBCS media, students' average cognitive score increased to 81.25, indicating that they had successfully reached the Biology KKM.

The effectiveness of game-based learning media in improving students' cognitive learning outcomes has been supported by previous research studies (Cheng & Annetta, 2012; Yu et al., 2021). Consistent with this, the studies conducted by Paramita et al. (2022) and Marlina et al. (2021) on the use of puzzles in biology learning also revealed a significant improvement in students' cognitive learning outcomes. The integration of puzzle games in the learning process can enhance students' understanding of concepts, aid in the retention of important terms, promote active student participation, and ultimately lead to improved learning outcomes (Bawazeer et al., 2022).

Board games, such as puzzles, serve not only as recreational activities but also as effective tools for facilitating learning. The challenges embedded within the game serve as motivational factors, encouraging students to actively engage in the learning process. This engagement necessitates the employment of various cognitive skills, such as reaction, critical thinking, judgment, and receiving feedback. Through the guidance and direction provided by teachers, students are able to achieve their desired learning outcomes (Tsai et al., 2019). Within the context of PBCS, students are challenged to answer all questions correctly and arrange the answer cards on the board to form an illustrative picture of the respiratory system when the puzzle board is flipped over. Even a single incorrect answer can disrupt the perfect formation of the picture or result in mismatched parts. Consequently, students are motivated to engage in group discussions and collaborate in order to identify the most appropriate answers to the questions posed.

The utilization of PBCS media actively involves students in the learning process, leading to a better understanding of the content compared to passive listening to teacher explanations (Hyun et al., 2017). Improved material comprehension serves as the primary reason for the observed enhancement in students' cognitive learning outcomes following the implementation of PBCS (Ceran & Ates, 2020). PBCS media offers students a novel learning experience that fosters increased enthusiasm and interest in the subject matter. Additionally, the collaborative nature of PBCS, which involves group work and discussions, serves as a motivational factor for students, driving them to actively contribute and strive for victory in the game (Harding, 2018). The higher the level of student interest in learning, the greater the learning outcomes that can be achieved (Dahliani et al., 2020).

The question cards used in PBCS encompass real-life cases related to respiratory system disorders frequently encountered in the local community. The inclusion of case studies has been proven to enhance students' scores in the cognitive domain (Amos, 2021). Furthermore, research conducted by Bonney (2015) compared the test scores of classes that incorporated case studies with control classes that did not employ case studies. The results indicated that students taught with case studies achieved an average score that was 18% higher than the group

of students who did not receive case study instruction. Engaging with case study questions promotes critical thinking skills and encourages students to move beyond mere factual recall when answering questions (Porzecanski et al., 2021). The critical thinking process facilitates a deeper understanding of the material, thereby improving students' cognitive learning outcomes (Tuaputty et al., 2021).

Student Response to Puzzle-Based Case Study

The effectiveness of Puzzle-Based Case Study (PBCS) media in fostering cognitive learning outcomes in students has been examined, along with students' responses to the use of this media. To understand students' perspectives following their engagement with PBCS media, a series of semi-structured interviews were conducted. Four students willingly volunteered to participate in these interviews. Initially, the students were asked about their overall impressions after playing the PBCS, followed by a discussion on the knowledge they acquired through the use of this media. Additionally, the students provided suggestions for improving the PBCS media. Each student's response is identified using the coding system (S) followed by a number (e.g., S1 refers to the first student interviewed). One student provided a detailed impression of their experience with the PBCS game:

> *S1: The puzzle game presented quite a challenge. We found it difficult to solve, but we persisted in our efforts to find the answers to each question in order to correctly arrange the pictures. The questions were not only challenging in themselves, but we also had to contend with the limited time and the need to complete the puzzle faster than the other groups.*

The students' responses regarding the difficulty level of the case study questions posed in the PBCS media underscore its character as not merely a test of students' ability to memorize information, but as a tool for facilitating deep thinking. The presence of images on the back of the answer card further motivates students to solve the PBCS. Moreover, the competitive element intrinsic to high school students (Wulandari, 2016) pushed the students to strive for accurate arrangement of the PBCS. The students also provided feedback concerning the variety of case studies related to disorders of the human respiratory system contained within the PBCS media. Their responses are as follows:

> *S2: We came across case studies that were previously unknown to us. This expanded our knowledge of disorders that can occur in the human respiratory system. We would appreciate the extension of this game to cover other subject matter as well.*
>
> *S3: By comprehending each clue presented within the case, we were able to determine the appropriate answer. This puzzle provided us with a fresh learning experience on respiratory system diseases, moving beyond mere rote memorization.*
>
> *S4: We discovered that there is a wide range of diseases that can impede the process of breathing. We often felt perplexed in finding the answers due to the multitude of disease types. It would be helpful to have some assistance cards to facilitate the puzzle-solving process.*
>
> *(Note: The information provided here is based on past interviews conducted with student participants. The aim was to examine their feedback and responses.)*

The students expressed interest when using PBCS media to learn about disorders in the human respiratory system. Student interest in the learning process is positively associated with cognitive learning outcomes (Dahliani et al., 2020; Ernawati et al., 2022). PBCS media provides students with new information related to the human respiratory system, fulfilling the purpose of learning media to impart new knowledge (Nurpratiwiningsih et al., 2018).

However, this study has limitations. The implementation of PBCS was limited to one class consisting of only eight students, and there was no control group used. Moreover, the

application of PBCS media focused solely on the human respiratory system. Future research should explore the effectiveness of PBCS across different biology topics using experimental and control groups to compare student learning outcomes. Introduction and demonstration of the media prior to implementation would also be beneficial to ensure students fully comprehend the rules and mechanics of the game, thereby optimizing its use. The findings of this study serve as a foundation for the development of media for other subjects, facilitating more active and comprehensive learning experiences.

CONCLUSION

The Puzzle Based Case Study media has been found to be valid, practical, and effective for the learning of human respiratory system material. The validation results indicate that both the material and the media have achieved a validation rate of 100%, while the validation rate by educational practitioners reached 98.6%. The practicality of the media was assessed through questionnaires administered to students and teachers, and it received a practicality score of 95.6%. The effectiveness of the media in enhancing cognitive learning outcomes was evaluated using N-Gain scores, which showed a score of 0.62 (meeting the criteria for medium effectiveness) and an effectiveness criterion of 62 (indicating moderate effectiveness).

RECOMMENDATION

The development of Puzzle Based Case Study (PBCS) media was conducted in a single class, which necessitates further research to assess the effectiveness of PBCS by comparing classes that do not utilize this media. Additionally, the current implementation of PBCS solely focuses on respiratory system material, thus it is imperative to incorporate other biological materials to evaluate the effectiveness of the media across different subject matters. Given the relatively limited scope of the study, it is crucial to expand the implementation of this media to a larger pool of research subjects. Furthermore, future research on the development of PBCS media can include a help card component that contains relevant theories related to the material. This addition would not only encourage students to solve case study problems, but would also deepen their understanding of the fundamental concepts within the learning material.

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