



TGT-Based Biology Snakes and Ladders Learning Media to Enhance Senior High School Students' Critical Thinking Skills on the Human Movement System

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ABSTRACT

Purpose of the study: This study aimed to develop a Teams Games Tournament (TGT)-based Biology Snakes and Ladders (ULTABI) learning media for the topic of the Human Musculoskeletal System and to evaluate its validity, practicality, and effectiveness in improving students' critical thinking skills.

Methodology: The study employed a 4-D development model (Define, Design, Develop, and Disseminate). The research participants consisted of 20 eleventh-grade science students at Al-Wardah Educational Foundation Madrasah Aliyah. The research instruments included a needs analysis questionnaire, media and material expert validation sheets, teacher and student response questionnaires, and a critical thinking skills test based on Facione's critical thinking indicators. The data were analyzed descriptively using percentage analysis and the Normalized Gain (N-Gain) test.

Main Findings: The results showed that the ULTABI learning media achieved a very high level of validity, with scores of 93.18% from media experts and 86.90% from material experts. The media was also rated as very practical by both teachers (97.70%) and students (88.70%). The effectiveness test revealed a significant improvement in students' critical thinking skills, with the average score increasing from 39.65 on the pre-test to 91.30 on the post-test, resulting in an N-Gain score of 0.845, which falls into the high category. Among the critical thinking indicators, interpretation achieved the highest score, whereas evaluation showed the lowest achievement.

Novelty/Originality of this study: The Teams Games Tournament (TGT)-based ULTABI learning media is proven to be valid, practical, and effective in enhancing students' critical thinking skills on the topic of the Human Musculoskeletal System.

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1. INTRODUCTION

The development of science and technology in the 21st century demands that the education world produces graduates who not only master knowledge but also have higher order thinking skills, especially critical thinking skills [1], [2]. These skills include the ability to analyze information, evaluate evidence, solve problems,

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and make decisions logically and systematically. In learning biology, critical thinking is really important because the material studied isn't just facts, but also concepts, principles, and scientific processes that are all interconnected [3], [4]. Therefore, biology learning needs to be designed innovatively so that it can encourage students to actively, reflectively, and meaningfully build knowledge.

One of the biology topics that has a high level of complexity is the Human Movement System. This topic covers the structure and function of bones, joints, muscles, movement mechanisms, and various disorders of the movement system that require the ability to analyze between concepts [5], [6]. However, the learning process at school is still largely dominated by lecture methods and the use of textbooks, so learning tends to be teacher-centered. This situation causes students to memorize concepts more than truly understanding them, resulting in low learning participation and underdeveloped critical thinking skills [7], [8].

One way to address this problem is to develop learning media based on educational games that can create an active and enjoyable learning atmosphere. Educational snakes and ladders games give students the chance to learn by answering questions, analyzing problems, discussing, and solving cases collaboratively [9]-[11]. The effectiveness of this media can be improved by applying the Teams Games Tournament (TGT) learning model, which integrates group collaboration, academic games, tournaments, and group rewards. Combining the snakes and ladders media with the TGT model is expected to boost learning motivation, student interaction, and at the same time train critical thinking skills through an interactive and meaningful learning experience [12], [13].

Based on the initial observations at Madrasah Aliyah Yayasan Pendidikan Al-Wardah for 11th-grade science students, biology learning is still dominated by the use of textbooks, simple presentations, and lectures, while game-based learning media has not been utilized optimally. In the Human Movement System topic, most students have difficulty understanding the relationships between concepts, analyzing how the movement organs work, and explaining various disorders of the movement system scientifically. This is seen from the low participation of students in discussions, limited ability to present arguments based on evidence, and underdeveloped critical thinking skills. Therefore, this study aims to develop and validate the Biology Snakes and Ladders learning media based on Teams Games Tournament (ULTABI) as a valid, practical medium that can improve students' critical thinking skills in the Human Movement System topic. Previous research [14], [15] showing that the use of innovative learning media and cooperative learning models can improve the quality of the biology learning process. Game-based learning media (educational games) have been proven to increase learning motivation, active participation, learning outcomes, and higher-order thinking skills because they provide interactive and contextual learning experiences. On the other hand, research [16], [17]. The Teams Games Tournament (TGT) learning model has been widely reported to be effective in improving cooperation, social interaction, learning outcomes, and student engagement through academic game activities and inter-group competitions.

However, those studies still leave some research gaps. First, the research [18] developing Snakes and Ladders media or applying the TGT model separately, so there hasn't been much research that integrates both into a single learning product designed systematically. Second, research [19] It mostly measures improvements in cognitive learning outcomes and learning motivation, while the development of media specifically aimed at enhancing critical thinking skills is still relatively limited. Third, research [20] Regarding the development of game-based learning media for the Human Movement System material at the Madrasah Aliyah level, especially those that go through validation stages by media experts, content experts, and educational practitioners, it's still rarely done. Therefore, there is a need for learning media innovations that are not only engaging and interactive but also able to facilitate the development of students' critical thinking skills according to the demands of 21st-century learning.

The novelty of this study lies in the development of the Teams Games Tournament (TGT)-Based Biology Snakes and Ladders (ULTABI) learning media, which integrates an educational board game with the complete syntax of the Teams Games Tournament (TGT) model into a single instructional medium specifically designed to enhance students' critical thinking skills. Unlike previous studies, which generally employed the snakes and ladders game as an assessment tool or a learning game to improve academic achievement, the ULTABI media incorporates critical thinking-based questions, challenge cards, contextual case studies, collaborative group discussions, academic tournament mechanisms, and a group reward system that fully aligns with the characteristics of the TGT learning model.

Furthermore, this study extends beyond evaluating the effectiveness of the learning media by conducting a comprehensive product development and validation process to ensure that the media meets the criteria of validity, practicality, and educational usefulness in biology instruction. The objectives of this study were to develop and validate the Teams Games Tournament (TGT)-Based Biology Snakes and Ladders (ULTABI) learning media for the topic of the Human Musculoskeletal System, as well as to examine its validity, practicality, and effectiveness in improving the critical thinking skills of Grade XI science students. Therefore, this study is expected to contribute to the advancement of cooperative game-based learning media while providing practical guidance for biology teachers in designing more innovative instructional activities to foster

students' critical thinking skills in learning the Human Musculoskeletal System at Al-Wardah Educational Foundation Madrasah Aliyah.

2. RESEARCH METHOD

This research is research and development (Research and Development/R&D) aimed at developing a Teams Games Tournament-based Snakes and Ladders learning media (ULTABI) on Human Movement System material and testing its validity, practicality, and effectiveness in improving the critical thinking skills of 11th-grade science students. The study uses the 4-D development model (Define, Design, Develop, Disseminate) developed by [21], [22] because it has systematic stages, starting from needs analysis, design, development, to the dissemination of the product. Through this model, the media developed is expected to meet the criteria of being valid, practical, and effective. The research stage flow is shown in Figure 1.

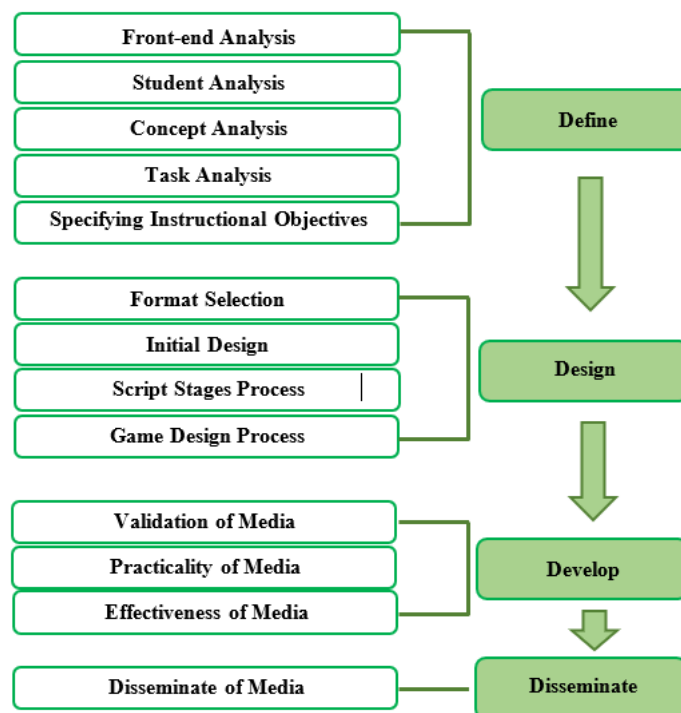


Figure 1. 4-D Model Design

The research was carried out at Madrasah Aliyah Yayasan Pendidikan Al-Wardah, Jalan Pasar VII, Percut Sei Tuan District, Deli Serdang Regency, North Sumatra. The research subjects consisted of 20 eleventh-grade science students who were involved in the limited trial phase. In addition, the study also involved validators, including one media expert, one material expert, and one question expert to assess the quality of the developed product. The define stage was carried out through a needs analysis, which includes front-end analysis, student characteristic analysis, concept analysis, task analysis, and learning objectives analysis as the basis for developing the media [21]. The data at this stage was obtained through biology teacher interview guidelines, teacher needs analysis questionnaires, and student needs analysis questionnaires.

The design stage involves preparing the learning materials, selecting the media, determining the game format, and creating an initial prototype of the ULTABI media using the Canva application. The media is developed in the form of a snakes and ladders game that integrates the Teams Games Tournament (TGT) syntax. Next, the development stage is carried out through validation by media experts, material experts, and instrument experts, then revised based on the validators' suggestions until a feasible product is obtained. Once validated, the media's practicality is tested through teacher and student response questionnaires, while its effectiveness is measured using a critical thinking skills test consisting of six essay questions based on critical thinking indicators. The indicators in this study are interpretation, analysis, inference, evaluation, explanation, and self-regulation [23]. The final stage, which is disseminate, is carried out on a limited basis by introducing the media to 11th-grade Biology teachers as an alternative learning media for the Human Movement System material.

The research instruments consist of interview guidelines, teacher and student needs analysis questionnaires, media expert validation sheets, material expert validation sheets, test instrument validation sheets, teacher response questionnaires, student response questionnaires, and critical thinking skills tests. The research data were analyzed descriptively, both quantitatively and qualitatively. Qualitative data, in the form of

comments and suggestions from validators, were used as the basis for media revisions, while quantitative data, in the form of validity, practicality, and effectiveness scores, were analyzed using percentages based on a four-point Likert scale [24]. The percentage of validity and practicality is calculated using the following formula.

$$\text{Percentage (100\%)} = \frac{\text{Score Obtained}}{\text{Score Maximum}} \times 100\% \dots (1)$$

Table 1. Criteria for Validity Test Assessment Results

Percentage (%)	Assessment Criteria
80.00–100.00	Very Valid
60.00–79.99	Valid
50.00–59.99	Fairly Valid
0.00–49.99	Invalid

Table 2. Criteria for Practical Test Assessment Results

Percentage (%)	Criteria
81–100	Very Practical
61–80	Practical
41–60	Fairly Practical
21–40	Not Practical

$$\text{N-Gain} = \frac{\text{Score posttest} - \text{Score pretest}}{\text{Maximum value} - \text{Score pretest}} \times 100\% \dots (2)$$

Description:

N-Gain = The value of improvement in learning outcomes or critical thinking skills

Post-test Score = The score obtained by students after the learning process

Pre-test Score = The score obtained by students before the learning process

Maximum Score = The highest score that can be achieved on the test

Table 3. N-Gain Interpretation Criteria

N-Gain Value	Criteria
$g > 0.70$	High
$0.30 < g \leq 0.70$	Moderate
$g \leq 0.30$	Low

3. RESULTS AND DISCUSSION

This research presents the findings on the development of the Ular Tangga Biologi learning media based on the Teams Games Tournament (ULTAB) for the Human Movement System material. The research findings are explained according to the 4-D development model stages (Define, Design, Develop, and Disseminate), which cover the media development process, validation results, practical tests, and effectiveness tests.

Define

The initial analysis results at the define stage showed that Biology learning at Al-Wardah Educational Foundation Madrasah Aliyah was still predominantly based on the use of textbooks and conventional teacher-centered learning methods. The Human Musculoskeletal System material was mostly presented through descriptive conceptual mastery, which provided limited opportunities for students to develop critical thinking skills through activities involving analysis, evaluation, and problem-solving. The analysis of students' characteristics revealed that most students experienced difficulties in understanding abstract concepts, particularly those related to the Human Musculoskeletal System. Students tended to be passive during learning activities, lacked confidence in expressing their opinions, and had not yet been able to connect the learned concepts with problems in everyday life. In addition, the needs analysis questionnaire indicated that students expected more interactive and engaging learning media that could increase their involvement and participation in the learning process.

The concept analysis results showed that the Human Musculoskeletal System material used in the school had not been presented comprehensively. The material was still primarily focused on the structure and function of bones, while discussions regarding movement mechanisms, disorders of the musculoskeletal system, and the application of concepts in daily life had not been optimally integrated. Meanwhile, the task analysis results indicated that learning activities were still dominated by memorization-based exercises and simple question-answer activities, which did not sufficiently provide learning experiences that trained students' analytical abilities, reasoning skills, and problem-solving competencies.

Based on the overall findings from the define stage, the need was identified to develop the Teams Games Tournament (TGT)-Based Biology Snakes and Ladders (ULTABI) learning media that aligns with students' characteristics and the Human Musculoskeletal System material. The analysis results also generated learning objectives oriented toward conceptual mastery, the application of concepts in real-life contexts, and the development of six critical thinking skill indicators, namely interpretation, analysis, inference, evaluation, explanation, and self-regulation. These indicators subsequently became the foundation for designing the learning media and developing the research instruments.

The analysis results at the define stage show that the Biology learning process at Madrasah Aliyah Al-Wardah Education Foundation is still dominated by the use of textbooks and conventional teacher-centered learning methods. This situation makes the learning process more focused on descriptive concept mastery rather than the development of higher-order thinking skills. These findings are in line with previous research. [25] who reported that students still have difficulty completing questions that require analytical, evaluative, and problem-solving skills because classroom learning still focuses a lot on mastering material and memorization. Likewise, [26] explains that biology learning dominated by lecture methods tends to limit students' active involvement in building knowledge, so critical thinking skills develop less optimally. Thus, the conditions found in this study show a gap between classroom learning practices and the demands of 21st-century learning, which emphasize developing critical thinking skills.

The analysis of student characteristics shows that most students have difficulty understanding abstract concepts in the Human Movement System material, lack confidence in expressing their opinions, and are not yet able to connect the concepts they learn with everyday life phenomena. These findings support previous research. [27] which states that low student participation in learning is often influenced by the use of less interactive teaching strategies, causing students to tend to be passive recipients of information. Research [28] It also explains that game-based learning media can boost students' motivation, engagement, and interaction because it provides a more contextual and meaningful learning experience. Therefore, students' need for more interactive learning media, as found in this study, shows that innovation in learning media is one of the important factors in improving the quality of the learning process.

Research findings also show that the Human Movement System material used in schools has not been presented comprehensively because it still focuses on the structure and function of bones, while movement mechanisms, movement system disorders, and the application of concepts in daily life have not been optimally integrated. In addition, learning activities are still dominated by memorization exercises and answering simple questions, so they do not yet give students the opportunity to develop analytical, reasoning, and problem-solving skills. These results are in line with previous research. [29] which states that presenting biology material in a partial way causes students to have difficulty connecting concepts and applying knowledge to solve contextual problems. Research [30] also found that learning that hasn't integrated problem-solving activities affects students' critical thinking skills, especially in biology material that is complex.

Based on the overall needs analysis results, this study formulated the development of a Biology Snakes and Ladders media based on Teams Games Tournament (ULTABI) that is tailored to student characteristics, the characteristics of the Human Movement System material, as well as critical thinking skill indicators according to Facione, namely interpretation, analysis, inference, evaluation, explanation, and self-regulation. These findings support the research [31] which explains that the Teams Games Tournament (TGT) learning model is able to increase student engagement through group work, discussion, and healthy academic competition. Besides that, the research [32] This shows that integrating the TGT model with interactive learning media can boost students' learning activities and critical thinking skills because it gives them opportunities to discuss, present arguments, and solve problems collaboratively. Therefore, the results from the define stage in this study serve as a solid foundation for developing ULTABI media as a learning solution that focuses not just on mastering concepts but also on fostering critical thinking skills in line with 21st-century learning demands.

Design

The results at the design stage indicate that an initial prototype of the Teams Games Tournament (TGT)-Based Biology Snakes and Ladders (ULTABI) learning media was successfully developed based on the needs analysis conducted during the define stage. The media was designed in the form of an educational game that integrates the Teams Games Tournament (TGT) learning syntax with several main components, including a game board, challenge cards, bonus cards, science zone cards, game instructions, game pieces, dice, and a storage box. The game board was designed with 100 squares equipped with snake and ladder illustrations, while the game cards consisted of three types, namely 6 challenge cards, 4 bonus cards, and 4 science zone cards. Therefore, the total number of cards used in this game was 14 cards. These cards contained questions, information, and challenges related to the Human Musculoskeletal System material.

In addition to developing the learning media, this stage also produced research instruments consisting of a media expert validation sheet, material expert validation sheet, teacher response questionnaire, student response questionnaire, and critical thinking skills test instruments in the form of pre-test and post-test questions.

All instruments were developed using a four-point Likert scale and adjusted to the aspects being assessed, namely the validity, practicality, and effectiveness of the developed learning media.

These findings show that the media design process is not just focused on presenting material, but also on providing a learning experience that allows students to interact, discuss, and solve problems collaboratively. These results are in line with research [33] which explains that game-based learning media will be more effective if designed as a learning environment that integrates game elements with learning objectives, so it can increase student engagement, learning motivation, and cognitive activities during the learning process. Likewise, [34] Through its meta-analysis, it shows that game-based learning media designed systematically can have a positive impact on intrinsic motivation, active participation, and students' learning outcomes.

The research results also show that ULTABI media not only produces a game prototype but also comes with the development of research instruments, including expert validation sheets, teacher and student response questionnaires, and critical thinking skills test instruments prepared based on indicators. The preparation of these instruments from the design stage shows that the media development process has considered product evaluation aspects thoroughly. These findings are in line with previous research [35] which states that in development research, the preparation of evaluation instruments needs to be done along with the design process so that each component of the product can be assessed objectively in terms of validity, practicality, and effectiveness. That way, the media developed not only meets aesthetic aspects but also has instruments that can systematically measure the quality of the product.

The input given by media experts and content experts during the validation process shows that the improvements to the media were not only made in the visual aspects but also in the content and learning implementation. Revisions such as refining the game board design, adjusting the size of the components, improving letter readability, aligning the questions with critical thinking skill indicators, adding reference sources to the knowledge zone cards, and adjusting the game rules to fit the Teams Games Tournament (TGT) syntax show that the design process is dynamic and focused on improving product quality. These findings support the research. [36] which states that the revision process based on expert input is an important stage in development research because it can improve the quality of content, appearance, and media functions before being implemented to users. Similar results were also reported by [37] who found that the TGT-based snakes and ladders media improved in quality after revisions were made to the visual design, material suitability, and game rules based on validator recommendations.

Refining the game rules to fit the Teams Games Tournament (TGT) syntax became one of the key findings in this study. In the initial prototype, the game mechanism still resembled a conventional snakes and ladders game, whereas after revising all the TGT learning stages — classroom presentation, team study, tournament, and group rewards — they were all integrated into the media. This shows that ULTABI media functions not only as an educational game but also as a cooperative learning tool that supports systematic learning activities. These findings are in line with previous research. [38] which explains that fully applying TGT syntax can improve the quality of student interactions, encourage group discussions, and give students the chance to develop critical thinking skills through argumentation and problem-solving processes. Thus, the full integration of TGT syntax in the ULTABI media is one aspect that sets this study apart from previous research on the development of snakes and ladders media, which generally still used conventional game mechanisms.

Overall, the results at the design stage show that the ULTABI media has been improved in terms of visual design, completeness of components, material quality, and learning mechanisms based on validator feedback. The revision process produced media that is more representative, easy to use, and aligned with the characteristics of the Human Movement System material as well as critical thinking skill indicators. These findings indicate that the design stage not only produced a learning media prototype but also created a refined product to serve as a foundation for the development stage, which involves testing the media's validity, practicality, and effectiveness in the learning process.

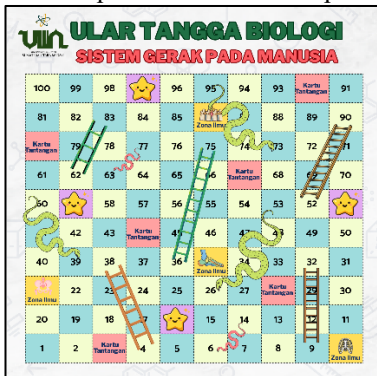
Develop

The review results from media experts and material experts provided several suggestions for improving the media prototype. Revisions in the media aspect included adding design elements to the back of the game board, enlarging the size of the game board, adjusting the number of snakes, ladders, bonus cards, challenge cards, and science zone cards to achieve better proportions, as well as improving the size and type of fonts on the game cards to enhance readability. Meanwhile, revisions in the material aspect included adjusting the questions on the challenge cards to align with critical thinking skill indicators, adding reference sources to the science zone cards, and refining the game rules to ensure consistency with the Teams Games Tournament (TGT) learning syntax.

The final results of the design stage produced the revised ULTABI media based on the validators' recommendations. The media consists of an improved game board, challenge cards, bonus cards, science zone cards, game instructions, four game pieces, one dice, a dice box, and a storage box containing all game components in a single package. Therefore, the developed media was ready to proceed to the next stage, namely

the develop stage. The results of the suggestions provided by media experts and material experts are presented in Table 4.

Table 4. Input from media experts and content experts Validation

Media Expert	Before Revision	After the Revision
The back design of the snakes and ladders board is too plain, so it's not very exciting for the back.	 The media just has a simple look with a plain white background and green and pink text that looks very plain and kind of boring.	 Added a back design that includes media identity like the media title 'Biology Snakes and Ladders: Human Movement System' in dark green and pink font, with the background given a slight touch of flower and leaf patterns, and the logo of the State Islamic University of North Sumatra Medan added so the media looks more professional and complete.
The snakes and ladders game board is too small and the number of squares doesn't match up with the distribution of snakes, ladders, bonus cards, challenge cards, and knowledge zone cards, making it hard for students to follow the game.	 A small game board with narrow squares, and the number of snakes, ladders, and cards is not proportional to the number of squares.	 The board size was increased with a bigger grid, and adjustments were made to the number of snakes (5), ladders (5), bonus cards (4), challenge cards (6), and knowledge zone cards (4) evenly spread across the 100 squares of the game board.
The font on the game cards is too small and unclear.	 The font on all three types of cards is small (5-7 pt) and uses a hard-to-read typeface called Glacial Indifference.	 The font size is increased to at least 8 pt with the easy-to-read Roboto typeface, and it comes with a bigger background to improve readability.

The material on the 2 challenge cards hasn't aligned with the critical thinking skill indicators tested in the pre-test and post-test on the movement system material.



Two challenge cards contain questions about interpretation that don't match the Facione critical thinking indicators used in the pre-test and post-test.



Both challenge cards were revised by adjusting the cognitive level of the questions on the pre-test and post-test, specifically on the interpretation indicator based on Facione's indicators.

On the science zone card that contains information about the human movement system, there isn't a clear reference listed for the information.



The science zone card contains factual information about the movement system without listing any sources, so the accuracy of the material can't be guaranteed.

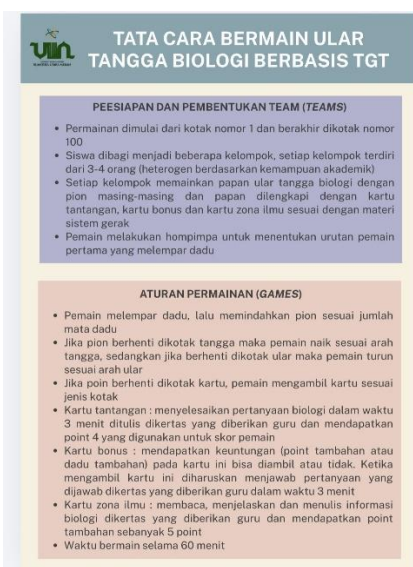


Every piece of information on the science zone cards comes with clear and reliable references, whether from biology textbooks or scientific journals, and is listed at the bottom of the card to boost the credibility of the material.

The way of playing snakes and ladders doesn't yet match the TGT (Team Games Tournament) syntax.



The game rules just adapt the conventional snakes and ladders game without integrating the TGT stages.



Media Expert	Before Revision	After the Revision
		 The game rules were revised by fully adapting the TGT syntax, including the class presentation stage, team learning, tournaments, and group awards. Each player must answer a question card before moving, and points are collected as a team.

The results at the development stage show that the Biology Snakes and Ladders Learning Media Based on Teams Games Tournament (ULTABI) has gone through a validation process by media experts and content experts before being trialed with students. The validation was conducted to assess the feasibility of the media in terms of design, content, language, presentation, and ease of use. The validation results from the media and content experts are presented in Tables 5 and 6.

Table 5. Media Expert Validation Results

No.	Assessed Aspect	Obtained Score	Maximum Score	Percentage (%)	Criteria
1	Design Quality and Visual Appearance	26	28	92.85%	Very Valid
2	Technical Quality and Media Construction	19	20	95.00%	Very Valid
3	Ease of Use	37	40	92.50%	Very Valid
	Average	27.33	29.33	93.18%	Very Valid

Based on Table 5, the validation results from media experts got an average score of 27.33 out of a maximum score of 29.33, with a validity percentage of 93.18%, so it falls into the very valid category. All the aspects evaluated, namely design and visual appearance quality, media technical and construction quality, and ease of use, got percentages above 90%.

Table 6. Results of Content Expert Validation

No.	Assessed Aspect	Obtained Score	Maximum Score	Percentage (%)	Criteria
1	Content Feasibility	32	36	88.88%	Very Valid
2	Language	17	20	85.00%	Very Valid
3	Material Presentation	24	28	85.71%	Very Valid
	Average	24.33	28.00	86.90%	Very Valid

Based on Table 6, the validation results from the content experts scored an average of 24.33 out of a maximum score of 28.00, with a percentage of 86.90%, which falls into the very valid category. These results show that the aspects of content feasibility, language, and material presentation have met the feasibility criteria to be tested in the next stage. After the validation process was completed, the ULTABI media was tested on 20 students and only 1 biology teacher, to find out the level of practicality in its use through teacher and student response questionnaires. The results of the practicality test are presented in Table 7.

Table 7. Results of Teacher and Student Response Questionnaires

Respondent	Number of Statements	Obtained Score	Maximum Score	Percentage (%)	Criteria
Students (n = 20)	12	42.60	48	88.70%	Very Practical
Teacher	11	43	44	97.70%	Very Practical

Based on Table 7, the teacher response questionnaire results obtained a practicality percentage of 97.70%, while the student responses reached 88.70%. Both results were categorized as very practical, indicating that the ULTABI media was easy to use in the learning process by both teachers and students. The validation results and practicality tests demonstrate that the ULTABI learning media has fulfilled the criteria of being very valid and very practical, making it feasible to proceed to the effectiveness testing stage.

The research findings at the develop stage showed that the Teams Games Tournament (TGT)-Based Biology Snakes and Ladders (ULTABI) learning media achieved a very high level of validity based on assessments from both media experts and material experts. The media expert validation obtained a percentage score of 93.18%, while the material expert validation achieved 86.90%, with both results classified as very valid. These findings indicate that the developed media met the aspects of design quality, media construction, ease of use, content feasibility, language quality, and material presentation before being implemented with students. The results also demonstrate that the revision process based on validator feedback successfully improved the quality of the media, making it more suitable for students' characteristics and aligned with the intended learning objectives.

The high level of validity of ULTABI media aligns with the research [39] who developed a Snakes and Ladders biology media on the topic of enzymes and carbohydrate metabolism. The study reported that the media received a very valid category after going through the validation process by media and material experts, mainly due to the material's alignment with the curriculum, attractive visual display, and ease of use in the learning process. Similar results were also found by [40] which states that expert validation is an important stage in development research because it ensures the alignment between learning objectives, media characteristics, and learners' needs before the media is applied in the classroom. Thus, the validation results in this study show that the ULTABI media has met the feasibility standards as a biology learning tool.

The research results also show that all aspects of expert media assessment scored over 90%, including design quality and visual appearance, technical and media construction quality, as well as ease of use. The high ratings in these areas indicate that the ULTABI media was designed with attention to learning design principles that can support students' comfort and engagement during the learning process. These findings support the study results. [41] which explains that game-based learning media will be more effective if it has an attractive visual appearance, easy-to-understand navigation, and can integrate game activities with learning objectives. Besides that, [42] Through the meta-analysis, it was concluded that the quality of game-based learning media design has a significant effect on students' critical thinking skills. Therefore, the high validity in the design aspect of ULTABI media shows that the media has met the characteristics of learning media that support an interactive learning process.

In terms of the material aspect, the validation results showed that the media received a very valid category for content feasibility, language, and material presentation. This finding indicates that the Human Movement System material presented in the media is in line with the learning outcomes, uses easy-to-understand language, and is organized systematically. These results are in line with previous research [43] who reported that game-based learning media will be more effective if the material presented is not only scientifically accurate but also arranged contextually and in accordance with the students' cognitive development level. In addition, [44] explaining that content quality is a key component in developing learning media because it determines the media's success in helping students build a complete conceptual understanding.

Besides validity, the research results show that the ULTABI media has a very high level of practicality, as indicated by a 97.70% response from teachers and an 88.70% response from students. These results suggest that the media is easy to use, easy to understand, and can be applied in the learning process without significant problems. The high response from teachers indicates that the media helps them manage learning, while the high response from students shows that the media can create an engaging learning experience and encourage active participation during lessons.

The finding supports the research results [45] who reported that the biological snakes and ladders media received a very practical rating because it is easy to operate, has clear instructions for use, and can increase student participation during learning. Similar results were also found by [46] which states that learning media combined with a cooperative learning model provides a high level of practicality because students can learn through interaction, discussion, and game activities at the same time. Thus, the practicality of ULTABI media is not only influenced by the physical design of the media but also by the integration of the Teams Games Tournament (TGT) syntax that provides a systematic learning flow that is easy for both teachers and students to apply.

Overall, the results at the development stage show that the ULTABi learning media has met two main criteria in development research, namely validity and practicality, making it feasible to move on to the effectiveness testing stage. The high level of validity indicates that the media meets quality standards in terms of design and content, while the high level of practicality suggests that the media can be used optimally in Biology learning. These findings also show that integrating educational game media with the Teams Games Tournament (TGT) model can produce learning media that not only meets product development standards but also aligns with the needs of teachers and the characteristics of students in 21st-century learning.

Disseminate

After the Biology Snakes and Ladders Media Based on Teams Games Tournament (ULTABi) was revised according to the validator's input, the media was tested on a limited basis with 11th-grade science students at Madrasah Aliyah Yayasan Pendidikan Al-Wardah to see how effective it was in improving critical thinking skills. The effectiveness was measured using pre-tests and post-tests that had been validated by experts. The test instruments were designed based on six indicators of critical thinking skills, namely interpretation, analysis, inference, evaluation, explanation, and self-regulation.

Table 8. Results of the Pre-test and Post-test Effectiveness of Students' Critical Thinking Skills

Pre-test	Post-test	Skor N-Gain	Persentase (%)	Criteria
39.65	91.30	0.845	84.53 %	High

Based on Table 8, the students' average pre-test score was 39.65, which increased to 91.30 in the post-test. Analysis using N-Gain gave a value of 0.845 with a percentage of 84.53%, which falls into the high category. These results show an improvement in students' critical thinking skills after using the Teams Games Tournament-based Biology Snakes and Ladders (ULTABi) learning media on the Human Movement System material. To get an idea of the achievement of each aspect of critical thinking skills after implementing the Teams Games Tournament-Based Biology Snakes and Ladders (ULTABi) learning media, an analysis was conducted on six indicators of critical thinking skills, including interpretation, analysis, inference, evaluation, explanation, and self-regulation. The analysis was based on the average scores obtained by students for each indicator after the learning activities. The results of the analysis showed a variation in achievement for each critical thinking skill indicator. The distribution of average scores for each indicator is shown in Figure 2.

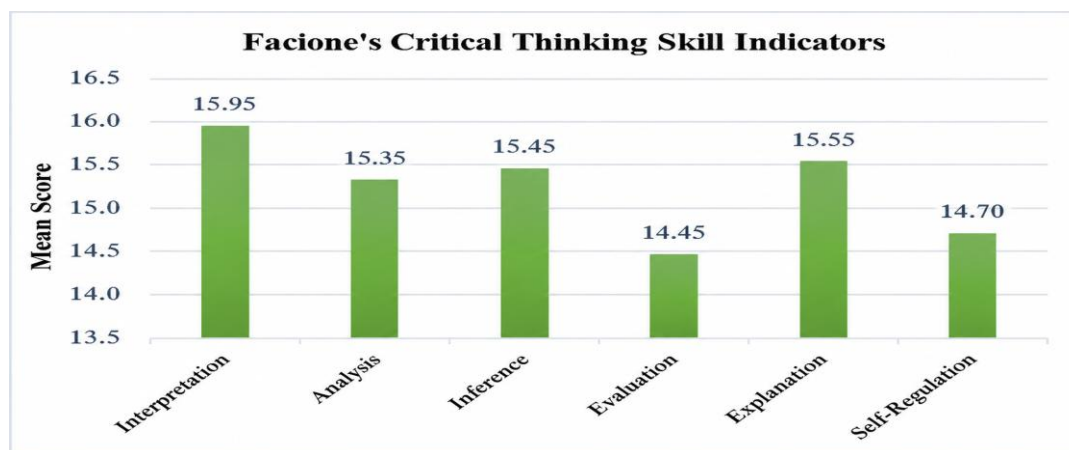


Figure 2. Average Scores of Critical Thinking Skills Indicators

Based on Figure 2, the interpretation indicator got the highest average score of 15.95, followed by explanation at 15.55, inference at 15.45, analysis at 15.35, self-regulation at 14.70, and evaluation at 14.45. These results show that all critical thinking skill indicators received relatively high average scores, with interpretation being the highest and evaluation being the lowest after using the Ular Tangga Biologi-based Teams Games Tournament (ULTABi) learning media. The research results at the dissemination stage show that the Teams Games Tournament-Based Biology Snakes and Ladders learning media (ULTABi) is effective in enhancing students' critical thinking skills on the Human Movement System material. This effectiveness is shown by the increase in the average pre-test score from 39.65 to 91.30 in the post-test, with an N-Gain value of 0.845 or 84.53%, which falls into the high category. These findings indicate that using ULTABi media can bring significant improvements in students' critical thinking skills after participating in the learning process. The increase suggests that integrating game media with cooperative learning models provides a more active learning experience, allowing students not only to gain conceptual knowledge but also to be involved in analysis, reasoning, and problem-solving processes.

The findings of this study are in line with previous research [47] which reports that the implementation of the Teams Games Tournament (TGT) model has a positive effect on improving students' critical thinking skills because learning takes place through group discussions, academic competitions, and interaction among students. Research [48] It also shows that the TGT model can significantly improve critical thinking skills compared to conventional learning because students get the chance to construct knowledge through teamwork and collaborative problem-solving. The similarity of these results indicates that the main features of TGT, namely learning in heterogeneous groups, academic tournaments, and giving group rewards, can create a learning environment that encourages active student engagement during the learning process.

The effectiveness of the ULTABI media is also inseparable from the characteristics of game-based learning media, which combines educational elements with playing activities. Research [49] explaining that game-based media can boost learning motivation and cognitive engagement because students learn through hands-on experience (learning by doing), making abstract concepts easier to understand. This is supported by the results of a meta-analysis [50] which shows that game-based learning has a positive impact on motivation, active participation, and learning outcomes when the games are designed according to learning objectives. In this study, the ULTABI media not only functions as an educational game but also integrates the Teams Games Tournament (TGT) syntax so that every game activity requires students to discuss, answer questions, analyze cases, and provide scientific reasoning for their chosen answers. This setup allows students to build knowledge through social interaction while also practicing critical thinking skills.

Analysis of six critical thinking skill indicators shows that the interpretation indicator scored the highest on average (15.95), followed by explanation (15.55), inference (15.45), analysis (15.35), self-regulation (14.70), and evaluation (14.45). The high achievement in the interpretation indicator indicates that students are able to identify, understand, and communicate information obtained from the material or problems presented in the learning media. These findings support previous research. [51] which explains that the syntax of Teams Games Tournament gives students the chance to interpret information through group discussions and academic tournaments, so their skills in understanding the meaning of information develop more optimally. In addition, the high scores on the inference and analysis indicators show that students are able to connect various pieces of information and draw conclusions based on the available evidence. These results are in line with research [52] which states that collaborative activities in the TGT model encourage students to use logical reasoning when solving problems together.

Even though all the indicators scored relatively high, the self-evaluation and self-regulation indicators still showed lower achievements compared to the other indicators. These results indicate that students' abilities to critically evaluate arguments and to monitor and reflect on their own thinking process still need improvement. These findings are in line with research [53] which states that the ability to evaluate and regulate oneself is the most complex aspect of critical thinking because it requires metacognitive skills, reflection, and the ability to build arguments based on scientific evidence. Therefore, even though the ULTABI media has been able to improve all indicators of critical thinking, developing learning activities that focus more on reflection, scientific argumentation, and evaluation of the solutions produced needs to be a focus in the next implementation.

Overall, the research results show that the Biology Snakes and Ladders media based on Teams Games Tournament (ULTABI) is an effective learning tool for improving students' critical thinking skills on the Human Movement System material. This success is shown not only by the high N-Gain scores but also by improvements across all indicators of critical thinking skills according to [54]. This finding strengthens the research results [55] who reported that the TGT-based snakes and ladders media can improve students' critical thinking skills through collaborative and enjoyable learning activities. However, this study has a more specific contribution because it develops the ULTABI media, specially designed for the Human Movement System material by integrating Facione-based critical thinking indicator questions, challenge cards, knowledge zone cards, and the complete TGT syntax. Thus, the ULTABI media not only serves as an educational game tool but also as a learning innovation that can support the development of critical thinking skills in line with the demands of 21st-century learning.

4. CONCLUSION

This study successfully developed a Teams Games Tournament-based Snakes and Ladders learning media (ULTABI) for Human Movement System material, which was proven to meet the criteria of being very valid, very practical, and effective in boosting students' critical thinking skills. The high validation results from media experts (93.18%) and subject matter experts (86.90%), positive responses from teachers (97.70%) and students (88.70%), as well as an N-Gain score of 0.845 in the high category, show that ULTABI media is suitable to be used as an innovative, interactive, and student-centered alternative for biology learning. The results of this study suggest that integrating educational games with the Teams Games Tournament (TGT) model can boost student engagement in the learning process through activities like discussions, collaboration, academic competition, and problem-solving, which can support the development of critical thinking skills—a key

competency for 21st-century learning. However, this study still has limitations because it was only trialed at one school with a relatively small sample size, focused only on the Human Movement System material, and hasn't tested the media's long-term effectiveness or compared it with a control class. Therefore, future research is recommended to involve a larger and more diverse sample, develop media in digital or app-based forms, apply it to other materials or subjects, and examine its effects on other higher-order thinking skills, such as creativity, problem-solving, science literacy, collaboration, and learning retention, so that the benefits of ULTABi media can be proven more comprehensively.

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AUTHOR CONTRIBUTIONS

Conceptualization, Methodology, Formal analysis, Data curation, Investigation, Writing – original draft preparation, and Writing – review and editing, E.D.U.; Supervision, Validation, and Writing – review and editing, M.N.A. Both authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

INFORMED CONSENT STATEMENT

Prior to participation, each subject was provided with a detailed explanation of the study's objectives, procedures, potential risks, and benefits. All participants voluntarily agreed to participate and signed a written informed consent form. All images in this article have been authorized and are the property of the authors.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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