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Development of an Educational “Snakes and Ladders” Game on the Human Respiratory System to Improve Junior High School Students’ Science Learning Outcomes

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ABSTRACT

Teaching science on the topic of the human respiratory system requires instructional media capable of increasing student engagement in developing conceptual understanding. However, classroom instruction is still dominated by lecture-based methods and the use of textbooks, resulting in suboptimal student participation and learning outcomes. This study aims to develop an educational “Snakes and Ladders” game for the human respiratory system unit and to test its validity, practicality, and effectiveness in improving the science learning outcomes of junior high school students. The study employed the Research and Development (R&D) method using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The research subjects consisted of 17 seventh-grade students at Muhammadiyah Aimas Junior High School. The research instruments included validation sheets for subject matter experts and media experts, a practicality questionnaire, a student response questionnaire, and learning outcome tests in the form of pretests and posttests. The data were analyzed using quantitative descriptive methods, including percentages and the N-Gain test. The results showed that the developed instructional material achieved a validity level of 92.59%, classified as “highly valid”; a practicality level of 98%, classified as “highly practical”; and an N-Gain value of 0.71, which falls into the “high” category. The results indicate that the educational “Snakes and Ladders” game meets the criteria of being valid, practical, and effective, making it suitable for use as an alternative teaching tool for science instruction on the human respiratory system. The use of this tool fosters a more interactive learning experience, increases student engagement, and supports improved science learning outcomes.

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INTRODUCTION

Science education is a learning process that is not only focused on mastering concepts but is also aimed at developing students' scientific process skills, critical thinking abilities, problem-solving skills, and scientific attitudes. In line with the implementation of 21st-century learning, the science learning process is expected to provide active, contextual, and meaningful learning experiences so that students can connect scientific concepts with phenomena encountered in daily life. Therefore, the selection of learning strategies, models, and media is a critical factor in supporting the achievement of science learning objectives (Hasan et al., 2021; Prasetyo et al., 2022). Various innovations in learning media have been developed to create more interactive learning experiences. Raharja et al. (2025) reported that the use of sensor-based smartphone physics modules can enhance the learning experience through hands-on activities, while the development of e-modules that integrate technology with local contexts can increase student engagement in science learning. These findings indicate that learning media designed to suit the characteristics of the subject matter and the students can make a positive contribution to the quality of science education.

One of the science topics that requires appropriate instructional media support is the human respiratory system. This topic involves interrelated and abstract biological concepts, requiring students to understand organ structure, gas exchange mechanisms, and the relationship between the respiratory system and various environmental factors. These characteristics often make it difficult for students to develop conceptual understanding when the learning process is still dominated by lectures and the use of textbooks as the primary learning resource. Previous research has also shown that science education still faces various conceptual challenges, one of which is the emergence of misconceptions that result in students' poor understanding of scientific concepts (Hidayat et al., 2020). This situation indicates that science education requires instructional media that not only present information but also help students build conceptual understanding through more active learning experiences.

Preliminary observations at Muhammadiyah Aimas Junior High School indicate that the science learning process is still dominated by the use of the lecture method, with textbooks serving as the primary learning resource. The use of interactive learning media remains relatively limited, resulting in a monotonous learning experience that fails to accommodate students' learning styles. As a result, students tend to be less active during the learning process, lose focus easily, and have difficulty understanding the material on the human respiratory system. This situation leads to low student achievement, with the majority failing to meet the Minimum Passing Criteria (KKM). These findings indicate a need for innovative learning media that can increase student participation while helping them understand science concepts in a more meaningful way.

One innovation with potential for application in science education is game-based learning. This approach integrates learning activities with elements of play, thereby creating a more enjoyable learning environment without compromising the achievement of learning objectives. Educational games also provide students with opportunities to interact, discuss, and solve problems collaboratively during the learning process. One form of educational game that is easy to develop is a modified version of the Snakes and Ladders game that incorporates learning materials, contextual questions, and activities aligned with science learning outcomes. Several studies have reported that the Snakes and Ladders game medium can enhance learning motivation, student engagement, and science learning outcomes (Janah & Mitarlis, 2023; Lantusia & Iswendi, 2023; Fauziyah et al., 2024; Azizah & Findrayani, 2024; Pertiwi et al., 2024). These findings indicate that educational games have the potential to support more interactive science learning.

Nevertheless, a review of various studies indicates that research on the "Snakes and Ladders" game as a teaching aid in science education is still dominated by studies that focus on assessing learning outcomes after the game has been used. Research that develops the

“Snakes and Ladders” game through a systematic development model while also evaluating the quality of the product based on validity, practicality, and effectiveness in the context of the human respiratory system remains relatively limited. Furthermore, the nature of the human respiratory system topic requires educational media that is not only visually engaging but also capable of helping students understand the relationships between concepts through interactive learning activities. Therefore, the development of educational media that meets product quality criteria while aligning with the characteristics of science content remains necessary to support more effective learning. Based on this description, this study aims to develop an educational “Snakes and Ladders” game on the human respiratory system that meets the criteria of validity, practicality, and effectiveness so that it can be used as an alternative learning medium to improve junior high school students’ science learning outcomes.

METHOD

This study is a research and development (R&D) project aimed at creating an educational “Snakes and Ladders” game to teach the human respiratory system and testing the quality of the developed product. The ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model was used because it provides a systematic development process, from needs analysis to product evaluation. The study was conducted at Muhammadiyah Aimas Junior High School during the even semester of the 2024/2025 academic year. The test subjects for the product were 17 seventh-grade students. Product validation was carried out by subject matter experts, media experts, and learning practitioners to obtain information regarding the media’s suitability before its implementation in the classroom.

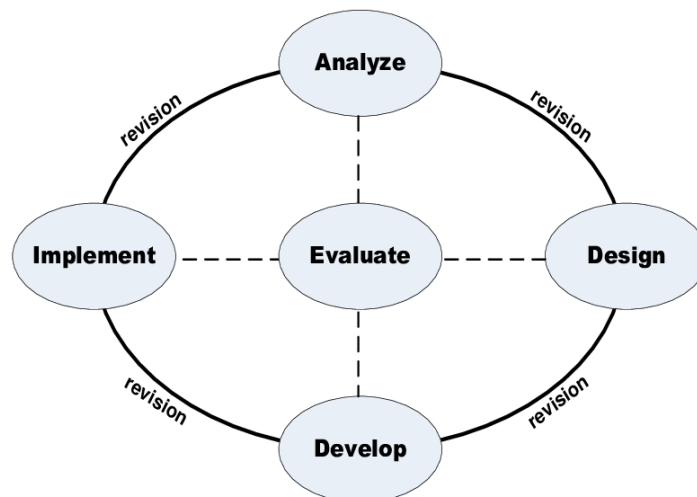


Figure 1. The ADDIE development model (Anggraeni et al., 2019)

The analysis phase was carried out through observations and interviews with the science teacher to identify student characteristics, learning problems, and instructional media needs for the human respiratory system material. The information obtained served as the basis for designing instructional media that met learning needs. The design phase includes developing media designs, creating storyboards, preparing content, developing validation instruments, designing student response questionnaires, and creating learning outcome assessment instruments in the form of pretests and posttests. The development stage involves creating the product based on the established design, followed by a validation process conducted by subject matter experts and media experts. Feedback from the validators is used to refine the product until it is deemed suitable for implementation in the classroom.

The implementation stage is carried out through a limited pilot test with seventh-grade students using the One-Group Pretest–Posttest Design, as shown in Table 1.

Table 1. One group pretest-posttest design

Group	Pretest	Treatment	Posttest
Experiment	O ₁	X	O ₂
Description: O ₁ = pretest score; X= learning using the educational "Snakes and Ladders" game; O ₂ = posttest score			

The evaluation phase aims to assess the quality of the instructional media based on expert validation results, student responses, and improvements in learning outcomes. The evaluation is conducted to determine the level of validity, practicality, and effectiveness of the developed instructional media.

The research instruments consist of (1) a content expert validation form, (2) a media expert validation form, (3) a student response questionnaire, and (4) learning outcome tests in the form of pretests and posttests. The validity and practicality of the media are analyzed using percentages, while the effectiveness of the media is analyzed using N-Gain to determine the improvement in students' learning outcomes after using the media.

RESULTS AND DISCUSSION

Results of the Development of an Educational Snakes and Ladders Game

The development phase resulted in an educational Snakes and Ladders game designed as a science learning tool on the human respiratory system for seventh-grade junior high school students. The game was developed using the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation. The resulting product is a set of learning materials consisting of a Snakes and Ladders game board, question cards, answer cards, game pieces, dice, and instructions for use, all designed in accordance with the learning outcomes for the human respiratory system topic.

The development of the educational game began with the analysis phase through observations and interviews with science teachers at Muhammadiyah Aimas Junior High School. The analysis revealed that instruction was still dominated by the lecture method, with textbooks serving as the primary learning resource, resulting in students lacking interactive learning experiences. Additionally, teachers had not yet utilized game-based learning materials capable of enhancing student participation during the learning process. These findings served as the basis for designing learning materials that align with both the characteristics of the subject matter and the needs of the students.

The design phase focused on developing the game materials, including the game board design, establishing game rules, developing question cards, creating learning materials, and designing assessment tools. The game was designed so that every play activity remains focused on achieving the learning objectives. Each game square contains an activity that encourages students to answer questions, discuss concepts, and relate material on the human respiratory system to phenomena encountered in daily life.

Next, during the development stage, all media components are finalized into a product ready for use in the classroom. The completed product is then validated by subject matter experts and media experts to gather feedback on the appropriateness of the content, presentation, language, and visual aspects of the media. The validation results serve as the basis for refining the product before it is implemented with students.

The mechanism for using the educational "Snakes and Ladders" game is designed to create an active and enjoyable learning environment. The game begins by rolling the dice to determine the number of steps the pawn takes. Students who land on a specific square must draw a question card and answer a question related to the human respiratory system. A correct answer allows the student to continue playing, while an incorrect answer results in a consequence according to the game's rules. In addition, some squares feature ladder and snake symbols that serve to reinforce the game's elements, thereby increasing students' motivation

to complete the game and reach the finish line. The flow of the developed game is presented in Figure 2.

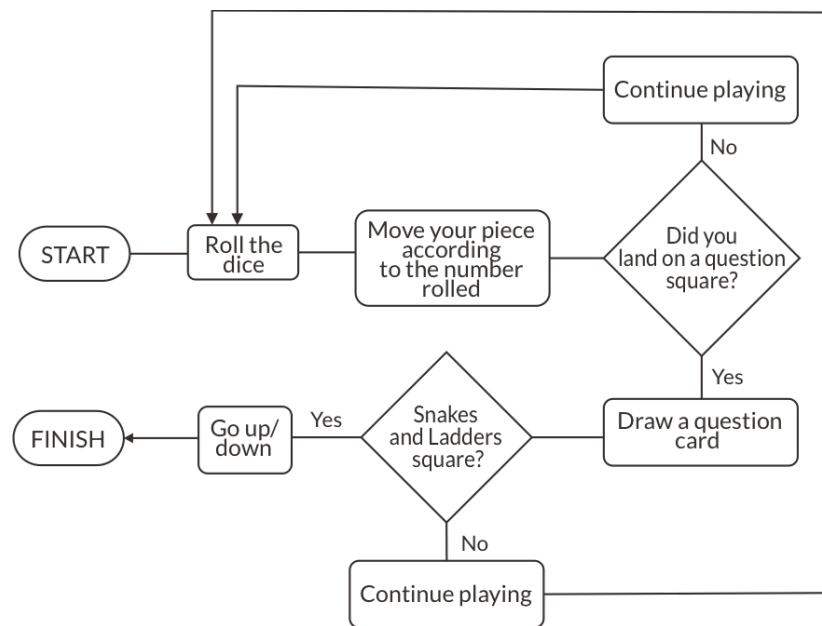


Figure 2. Flowchart of how to use the educational “Snakes and Ladders” game.

The media developed serves not only as a tool for play but also as a learning tool that integrates play with the process of knowledge construction. Each stage of the game is designed to engage students in the process of recalling, understanding, discussing, and communicating concepts related to the human respiratory system. Thus, the media not only creates a fun learning environment but also facilitates students’ active engagement in building their understanding of science concepts.

Validity of the “Snakes and Ladders” Educational Game

Media validity is the initial stage conducted to ensure that the developed product meets the eligibility criteria before being implemented in learning. The validation process is carried out by subject matter experts and media experts by assessing the appropriateness of the content, presentation, language, and visual aspects of the media. The feedback provided by the validators is used as a basis for refining the product so that the resulting media truly aligns with the learning objectives and characteristics of the learners.

Subject Matter Expert Validation

Subject matter expert validation aims to assess the alignment of the media’s content with learning outcomes, the accuracy of concepts, the completeness of the material, the presentation, and the use of language. The results of the subject matter expert validation are presented in Table 2.

Table 2. Results of Subject Matter Expert Validation

No	Aspect	Average score (%)	Category
1	Content validity	98	Highly Valid
2	Presentation validity	95	Highly Valid
3	Language validity	90	Highly Valid
Average core for all apsects		94,3	Sangat Valid

Based on Table 2, the educational “Snakes and Ladders” game medium achieved an average percentage of 94.3%, falling into the “highly valid” category. This percentage indicates that the material presented aligns with the competencies students are expected to achieve and accurately and systematically represents the concepts of the human respiratory system.

The content appropriateness aspect received the highest percentage at 98%, indicating that the material presented aligns with the learning objectives, student characteristics, and applicable scientific concepts. Meanwhile, the presentation appropriateness aspect received a percentage of 95%, indicating that the material was organized coherently and was easy to understand. The language appropriateness aspect received a score of 90%, indicating that the language used in the media was communicative and appropriate for the students' developmental level.

During the validation process, the validators also provided several suggestions to improve the product, including editorial revisions to some of the question cards, simplifying sentences to make them easier for students to understand, and adjusting scientific terminology to ensure consistency with the material on the human respiratory system. All of these suggestions were used as the basis for revising the product prior to the implementation phase.

Media Expert Validation

In addition to content validation, the media were also validated in terms of design and appearance to ensure that they are easy to use and capable of capturing learners' attention during the learning process. The aspects evaluated included overall appearance, quality of media content, and visual elements. The results of the media expert validation are presented in Table 3.

Table 3. Results of Media Expert Validation

No	Aspect	Percentage (%)	Category
1	General	90	Highly Valid
2	Content	95	Highly Valid
3	Visual	90	Highly Valid
Average validation percentage (%)		91,6	Highly Valid

The validation results show that the media achieved an average score of 91.6%, falling into the "highly valid" category. The content aspect received the highest score of 95%, while the general and visual aspects each received a score of 90%. These results indicate that the media features an attractive appearance, a balanced color scheme, a systematic layout, and easy-to-understand instructions. Additionally, the font size, illustrations, and game board design were deemed appropriate for middle school students, enabling the media to provide a more engaging learning experience compared to conventional media.

The validators also provided several suggestions for improvement, including refining the design of some icons on the game board, adjusting the font size on the question cards to make them easier to read, and adding usage instructions at the beginning of the game. All of these suggestions were incorporated into the revised product, and the educational media was deemed suitable for use in the implementation phase.

The validation results show that the educational "Snakes and Ladders" game meets the criteria for high validity, both in terms of content and media. The high level of validity indicates that the media development process was carried out systematically through the stages of needs analysis, design, development, validation, and revision. The validation process aims not only to assess the quality of the product but also to ensure that the media can support the achievement of learning objectives and is appropriate for the characteristics of junior high school students.

The high score in the content suitability aspect indicates that the material presented in the media aligns with the learning outcomes and is effective in helping students understand the concept of the human respiratory system. Meanwhile, the high scores in the visual aspect indicate that the media's design enhances the appeal of the learning experience, thereby potentially increasing students' attention and engagement during the learning process. This aligns with the view of Hasan et al. (2021), who state that instructional media designed according to students' characteristics will be more effective in supporting the learning process.

The findings of this study are also consistent with the research by Fauziyah et al. (2024), Janah and Mitarlis (2023), and Lantusia and Iswendi (2023), who reported that educational game-based media achieved a high level of validity after undergoing a validation process by subject matter experts and media experts. These consistent results indicate that the validation process is a crucial stage in development research to ensure that the resulting media meet quality standards before being used in instruction.

Furthermore, the results of this study reinforce the findings of Sirojjuddin et al. (2025), which show that the quality of instructional media is significantly influenced by the needs analysis process, systematic design, and product refinement based on validators’ feedback. Therefore, the high validity of the educational “Snakes and Ladders” game indicates that the developed product is of sufficient quality to be implemented in science instruction on the human respiratory system.

Practicality of the “Snakes and Ladders” Educational Game

The practicality of a medium refers to its ease of use in the learning process and its suitability for the needs of teachers and students. In this study, the practicality of the media was evaluated through assessments by education practitioners and student responses after the media was implemented in science lessons on the human respiratory system. The aspects evaluated included content appropriateness, presentation, language, ease of use, and student interest in the developed media.

Practicality According to Education Practitioners

The assessment by education practitioners aims to determine the extent to which the media can be used effectively in learning activities. A summary of the practitioners’ assessment results is presented in Table 4.

Table 4. Results of the Media Practicality Test by Education Practitioners

No	Aspect	Average score (%)	Categories
1	Content suitability	91.7	Very practical
2	Presentation suitability	91.7	Very practical
3	Language suitability	89.3	Very practical
Average score for all aspects		92	Very practical

Based on Table 4, the educational “Snakes and Ladders” game received an average score of 92%, falling into the “very practical” category. This score indicates that the medium is highly user-friendly in terms of content, presentation, and language use. Practitioners assessed that the game rules are easy to understand, the material is organized systematically, and the medium can be used without requiring complex additional resources.

In addition, the media is considered capable of helping teachers create more interactive learning experiences because game-based activities encourage students to discuss, answer questions, and actively participate during the learning process. These characteristics indicate that the media is not only academically sound but also easy to implement in science instruction in the classroom.

The high level of practicality of this educational game demonstrates that the “Snakes and Ladders” educational game is easy for both teachers and students to use without requiring special training. This is due to the game’s simple design, easy-to-understand rules, and presentation of material tailored to the characteristics of middle school students. Furthermore, the use of question cards integrated with the game board allows students to engage in a more active learning experience through discussion, collaboration, and problem-solving.

The findings of this study are consistent with the research by Janah and Mitarlis (2023), Lantusia and Iswendi (2023), and Fauziyah et al. (2024), which state that educational game-based media have a high level of practicality because they can increase student engagement during learning. The results of this study also reinforce the findings of Raharja et al. (2025)

that learning media designed according to student characteristics are easier to implement in the classroom and can improve the quality of the learning experience.

The Effectiveness of the “Snakes and Ladders” Educational Game

The effectiveness of the educational game was analyzed based on improvements in students’ learning outcomes after participating in lessons using the “Snakes and Ladders” educational game. Measurements were taken through a pretest administered before the lessons and a posttest administered after the lessons. Subsequently, improvements in learning outcomes were analyzed using N-Gain to determine the effectiveness of the educational game in enhancing students’ conceptual understanding.

Student Learning Outcomes

A summary of students’ learning outcomes before and after instruction is presented in Table 5.

Table 5. Comparison of Learning Outcomes Before and After Instruction

Variable	Average	Categories
Pretest	50	Low
Posttest	90	Very good
N-gain	0,7	High

Based on Table 5, students’ average scores increased from 50 on the pretest to 90 on the posttest. An analysis using the N-Gain method yielded a value of 0.71, which falls into the “high” category. These results indicate that the use of the educational “Snakes and Ladders” game contributed positively to improvements in students’ learning outcomes regarding the human respiratory system.

The improvement in learning outcomes indicates that the educational “Snakes and Ladders” game is more effective in supporting the science learning process than instruction that relies solely on lectures and textbooks. During the game, students not only answered questions but also engaged in discussions, provided reasons for their chosen answers, and received immediate feedback from both the teacher and their groupmates. These activities encouraged students to develop conceptual understanding through active learning experiences.

The success of this medium in improving learning outcomes is also influenced by the game’s characteristics, which enhance learning motivation. Elements of healthy competition, challenges presented through question cards, and interactions among students create a more enjoyable learning atmosphere, allowing students to focus more intently on the learning process. These conditions align with game-based learning theory, which states that integrating game elements into learning can increase students’ intrinsic motivation and engagement in knowledge construction.

The findings of this study are consistent with the results of studies by Azizah and Findrayani (2024), Fauziyah et al. (2024), Pertiwi et al. (2024), and Rahman and Fitriani (2023), which reported that educational games can improve learning outcomes through more interactive learning. Furthermore, the results of this study reinforce the findings of Fitriani et al. (2021), which showed that the use of instructional media tailored to students’ characteristics has a positive effect on science learning outcomes.

CONCLUSION

This study successfully developed an educational “Snakes and Ladders” game on the human respiratory system as a science learning tool for junior high school students using the ADDIE development model. Based on validation results by subject matter experts and media experts, the developed game met the criteria for high validity, while the practicality test results indicated that the game is highly practical for use in the learning process. Furthermore, the results of the effectiveness test showed that the use of this medium was able to improve student learning outcomes, as indicated by an increase in N-Gain scores in the high category. Thus, the

educational "Snakes and Ladders" game meets the three main indicators of quality for research and development products namely, validity, practicality, and effectiveness making it suitable for use as an alternative science learning medium for the human respiratory system.

The use of the educational "Snakes and Ladders" game provides a more interactive learning experience through playing, discussing, and solving problems related to the concept of the human respiratory system. These characteristics enable students to actively participate throughout the learning process, ensuring that learning is not only focused on conveying content but also on building conceptual understanding through meaningful learning experiences. Therefore, the developed educational game has the potential to serve as an innovative alternative in science education that teachers can implement to create a more engaging and student-centered learning environment.

This study has limitations because the product pilot test was conducted at a single school with a relatively small number of students and was applied only to material on the human respiratory system. Therefore, future research is recommended to implement the media in other science topics, involve a larger number of participants, and test the media's effectiveness using an experimental design that allows for comparison with a control class, thereby providing a more comprehensive picture of the media's effectiveness in science education.

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