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The Creation of the SnaPhys (Snake Physics) Game as a Learning Medium for Physics on Renewable Energy Topics

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Abstract
The quality of the learning process affects student learning outcomes. The learning process is still limited to the teacher's explanation and does not utilise learning media based on the characteristics of students. This impacts students' low motivation to learn, especially in Physics. This research aims to produce educational snake and ladders game products integrated with QR codes as an alternative physics learning media. The development model used is 4D. However, this research is limited to the 3D stage: define, design, and develop. The data collection technique used a questionnaire with a research subject of 1 expert. Experts will perform product validation in three aspects: technical, educational, and aesthetic. The results of data analysis showed that the technical aspect score was 17 with a percentage of 94.4%, the academic aspect score was 11 with a rate of 91.6%, and the aesthetic aspect score was 13 with a percentage of 86.6%. Thus, an average score of 41 with an average percentage of 91.1% was obtained so that the Snakes and Ladders game was included in the outstanding category and declared feasible to increase students' physics learning motivation.

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INTRODUCTION

The learning process aims to achieve behavioural changes that lead to self-development, including acquiring knowledge, mastery of specific disciplines, and forming attitudes and characters (Asnita & Wayong, 2022; Puspitarini & Hanif, 2019). Learning activities are closely related to teaching and are integral to the learning process (Asnita & Wayong, 2022). While students generally do learning, teaching remains the primary domain for teachers. The interaction between students and teachers significantly affects the success of the learning process (Napitupulu, 2019). Therefore, the design of an effective learning process by teachers is crucial as this significantly influences student learning outcomes. Student learning outcomes serve as a measure of the quality of the learning process that has been implemented (Sumardi et al., 2020). Learning becomes more effective when students are placed at the centre of the learning process

(Marpaung & Azzajjad, 2020), with teachers acting as facilitators and stimulators (Pradana, 2020). An optimal learning process should also allow students to construct their knowledge (Chyta et al., 2019).

Physics is a branch of science that studies natural phenomena and events in the universe (Harefa, 2019), focusing on discovering ideas or concepts and applying them in everyday life. However, students often face difficulty determining which concepts to apply when studying physics (Körhasan & Gürel, 2019). In addition, mathematical skills and scientific attitudes are also difficulties that students often face. Research by Sari et al. (2018) showed that in the physics final semester exam at three high schools in Surakarta, only 40% of students scored above the minimum competency standard. This indicates that student learning outcomes in physics are still relatively low. In addition, school physics teaching often emphasises teacher-centred explanations (Saleh, 2020), lacks active student participation, and focuses directly on solving mathematical problems. Such practices lead to low student motivation to learn physics (Budiarti & Jumadi, 2023; Sutarto et al., 2014). In contrast, high motivation towards learning can significantly improve the quality of the learning process (Puspitarini & Hanif, 2019).

Motivation significantly influences student learning outcomes (Yu et al., 2024). Students with high learning motivation tend to show enthusiasm in following the learning process, resulting in a better understanding of the material. This learning motivation can arise intrinsically, but can also be enhanced through stimuli provided by teachers in the learning environment (Puspitarini & Hanif, 2019). Developing interesting learning strategies is one way to increase students' learning motivation. Learning strategies include learning methods and media (Puspitarini & Hanif, 2019), one of which is through edutainment-based learning. Edutainment-based learning combines the concepts of education and entertainment (Purwanto, 2019), which aims to create a fun and engaging learning process (Regitanurvikasari et al., 2022).

One form of edutainment-based learning is through game-based learning. Game-based learning involves using games

in the learning process to fulfil students' cognitive needs and stimulate their motivation to learn (Alam, 2022; Calatrava et al., 2022; Malone, 1981). One type of educational game that can be developed is the Snakes and Ladders game. The Snakes and Ladders game is a board game that is usually played by two to four players (Ibam et al., 2018), with the characteristic images of snakes and ladders found on the game board (Kholipah et al., 2020).

Several previous studies have developed Snakes and Ladders games as learning media to support learning. Karimah et al. (2014) developed a Snakes and Ladders game for vibration and wave topics, while Guterres et al. (2018) created a digital version of this game for the topic of global warming. Permana et al. (2024) developed a digital Snakes and Ladders game that focuses on practising physics problems related to mechanics and fluid dynamics. These studies show that the Snakes and Ladders game can be utilised to increase students' learning motivation.

However, the development of Snakes and Ladders games for physics topics is still limited. Realising this gap, researchers are interested in developing Snakes and Ladders games as physics learning media, especially on renewable energy. This development aims to produce physics learning media that are of interest to and meet the needs of students. In contrast to previous research, the Snakes and Ladders game that will be developed will be innovatively integrated with QR code technology. Thus, this research focuses on developing Snakes and Ladders games integrated with QR codes for renewable energy topics. These are expected to create an edutainment-based learning environment and improve student learning outcomes in physics subjects.

METHOD

This research is categorised as R&D (Research and Development) using the 4D development model, which includes four stages: define, design, develop, and disseminate (Thiagarajan et al., 1974). However, this study is limited to the development or 3D stage, which focuses on expert validation. The define stage involves identifying specific problems through needs analysis, specification of learning objectives, and other analyses. The design stage includes designing the product to be

developed, while the development stage includes manufacturing the product and validation by experts.

The subject in this research is an expert, a lecturer from the Physics Education Study Programme at Sebelas Maret University (UNS) who teaches in the Physics Education Learning Media course. The data collection technique used in this study was a questionnaire. This questionnaire was used to collect validation results from experts covering three aspects of product evaluation: technical, educational, and aesthetic (Nurfadilah et al., 2021). Expert validation was conducted before the developed media products were trialled with students.

Each validation aspect was measured using a three-point quality scale: high quality (3), medium quality (2), and low quality (1). The questionnaire was designed as a closed survey, which required the expert to mark the quality assigned to each criterion. The framework of the validation instrument can be seen in Table 1.

Table 1. Instrumen of Expert Validation

No	Aspect	Indicator
1	Technical	Suitability of the product for the students' age
		Ease of use
		Age-appropriate language
		Clarity of game instructions
		Safety and durability of the product materials
2	Educative	Alignment with standards, objectives, and curriculum
		Appropriateness for developmental stages
		Encouragement of learning activities
		Stimulation of cognitive abilities
3	Aesthetica	Ergonomic design
		Portability
		Proportionality of dimensions
		Colour combination
		Font selection and size

The results of expert validation were analyzed both qualitatively and quantitatively. Qualitative data analysis was derived from feedback and suggestions provided by the expert to improve the media product. The expert validation scores were analyzed quantitatively and categorized based on the classification presented in Table 2 (Widoyoko, 2011).

Table 2. Criteria of Validation Product

Interval Score	Category
$38{,}82 < \bar{x}$	Very Good
$32{,}94 < \bar{x} \leq 38{,}82$	Good
$27{,}06 < \bar{x} \leq 32{,}94$	Enough
$21{,}18 < \bar{x} \leq 27{,}06$	Bad
$\bar{x} \leq 21{,}18$	Very Bad

In addition, the percentage of the expert validation score was calculated using Equation 1.

$$i = \frac{skor\ rata - rata}{skor\ maksimal} x\ 100\% \qquad (1)$$

Complement:

i = percentage for each aspect

RESULTS AND DISCUSSION

At the define stage, needs analysis and specification of learning objectives are conducted. This analysis is based on a literature review, which is the basis for designing the game to be developed. The analysis results found that among three high schools in Surakarta with a sample of 90 grade 11 students majoring in IPA, the motivation to learn physics was categorised as low to moderate (Sari et al., 2018). This indicates a lack of student interest in learning physics. Innovative learning media can be implemented to increase students' learning motivation in physics. Game-based learning is one of the practical and engaging learning media. Through the concept of learning while playing, this method can increase students' active participation, creativity, and learning motivation (Tapingkae et al., 2020). A literature review also revealed that one of the potential games to be developed is Snakes and Ladders. Some studies show that this game can make the learning process more enjoyable, which in turn can stimulate students' motivation to learn physics (Guterres et al., 2018; Karimah et al., 2014; Permana et al., 2024). Therefore, this research focuses on developing Snakes and Ladders games as physics learning media integrated with QR codes. The game is designed to be tailored to the needs of students and to achieve the learning objectives set.

At the design stage, the SnaPhys (Snake Physics) game was developed based on the results of the analysis that had been carried out. The game board was designed to be 45 cm x 33 cm, consisting of 100 numbered boxes, two card slots, and a QR code that provides game instructions. This physics-based Snakes and Ladders game is designed as an assessment tool that is a medium for practising questions. The questions are presented digitally using Google Forms, with links converted into QR codes. The game board is produced in print to encourage active classroom learning. Integrating QR codes linking the questions

with the game will facilitate recording student answers in a database and improve students' digital literacy.

The third stage is the development stage. At this stage, the SnaPhys game was developed based on the design that had been made previously, then continued with product validation by experts. The game was designed using Canva, which was chosen for its user-friendly interface and free access. The game design comprises two main components: the game board and the cards. The cards included 'magic cards' and 'instruction cards'.

The game board consists of 100 squares numbered from 1 to 100. As in the traditional Snakes and Ladders game, SnaPhys also includes illustrations of snakes and ladders. In addition, images relevant to renewable energy have been added. QR codes are integrated into the design, which appear on certain boxes and in the game instructions. This QR code directs students to Google Forms containing questions about renewable energy, including conceptual and mathematical problems. The final design of the game board is shown in Figure 1.

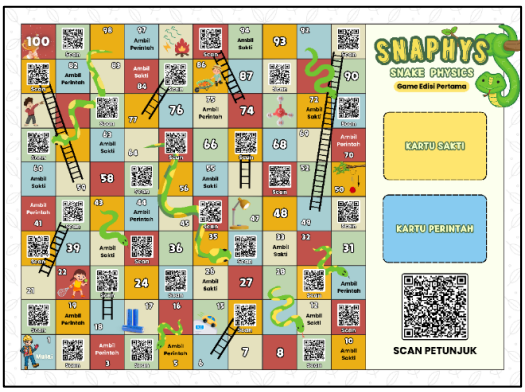

Figure 1. Result of Game Board

The SnaPhys game comes with two game cards: magic and instruction cards. The magic cards contain information that can help students when they have difficulty answering the questions. Meanwhile, the instruction cards contain commands such as 'go forward five steps,' 'go back three steps,' and so on. Both cards are designed with different background colours to make it easier to differentiate them. The design of the developed game cards can be seen in Figures 2 and 3.

(a) Cover (b) Material

Figure 2. Result of Kartu Sakti

(a) Cover (b) Content

Figure 3. Result of Kartu Perintah

Magic cards are essential in helping students understand the physics material taught in the game. With these cards, students who may find it difficult to answer questions can easily access information that can help them. This is expected to improve students' understanding of the renewable energy topics taught in the game. Meanwhile, the instruction cards aim to make the game more dynamic and engaging by providing challenges in unexpected moves. The commands on these instruction cards add an entertainment element to the game and stimulate active interaction between students during the learning process.

With the integration of these two types of cards, the SnaPhys game is expected to create a fun and effective learning experience that can improve students' understanding of physics concepts, especially those related to renewable energy. The clear and easily distinguishable card design also aims to minimise confusion, so that students can focus on learning while playing. Furthermore, the research product was subjected to expert validation, concentrating on technical, educational, and aesthetic aspects. The results of expert validation are presented in Table 3.

Table 3. Results of Expert Validation

No	Aspek	Skor	Skor Maks	%
1	Teknis	17	18	94,4
2	Edukatif	11	12	91,6
3	Estetika	13	15	86,6
Total		41	45	91,1

Table 3 presents a quantitative product analysis based on the expert validation results. The technical aspect scored 17 with a percentage of 94.4%, the educational element scored 11 with a rate of 91.6%, and the aesthetic aspect scored 13 with a percentage of 86.6%. The average score obtained was 41 with an average percentage of 91.1%, which indicates that the SnaPhys game can be categorised as an excellent product. The qualitative analysis included expert feedback and suggestions, such as the need for more attention to the use of italicised format for some terms and

considerations regarding the quality of paper materials and the safety of the card shape to prevent potential harm to students.

The use of educational games in classroom learning has been shown to significantly impact the learning process (Cheung & Ng, 2021). The selection and development of games as learning tools must consider various technical, educational, and aesthetic aspects (Nurfadilah et al., 2021). As an educational game, the game developed must contain educational elements per the learning objectives. Both modern and traditional games can be modified into educational games according to specific needs. Snakes and Ladders, a traditional game (Setiani & Handayani, 2022), can stimulate students' physical, emotional, and cognitive development (Naafi & Irawan, 2022).

The primary purpose of using games in learning is to increase students' motivation in learning. One of the important things to consider is the use of colour. Bright colours can attract students to use the game (Thung & Ahmad, 2022). Therefore, the SnaPhys game's design integrates various bright colours. In contrast to the development of the Snakes and Ladders game by Permana et al. (2024) and Guterres et al. (2018), which are presented in digital form, the SnaPhys game is presented in print. This is because print media can increase student learning activities directly and tangibly (Hermansyah et al., 2023). The Snakes and Ladders game developed by Karimah et al. (2014) consists of question cards and answer cards.

In contrast, in the SnaPhys game, the questions are integrated with a QR Code, making it easier for students to answer. In addition, students are not immediately told the correct answer when they answer incorrectly, which requires them to keep trying until they get the correct answer. This approach encourages more profound understanding and better mastery of the material. Several studies have shown that using learning media in the form of Snakes and Ladders games effectively increases students' learning motivation. The results of data analysis also show that SnaPhys games are very suitable for the physics learning process.

CONCLUSION

This study has produced a physics learning media product in the form of an educational game, SnaPhys (Snake Physics), integrated with QR Codes on the topic of renewable energy. The expert validation results show that the technical aspect scored 17 with a percentage of 94.4%, the educational aspect scored 11 with a percentage of 91.6%, and the aesthetic aspect scored 13 with a percentage of 86.6%. Therefore, the average score obtained is 41 with an average percentage of 91.1%, categorizing this Snakes and Ladders game as excellent and deemed suitable for use in physics learning.

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