



CREATION OF EDUCATIONAL GAME-BASED PHYSICS LEARNING MEDIA FOR RENEWABLE ENERGY MATERIAL

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ABSTRACT

The quality of the learning process dramatically affects student learning outcomes. The learning process is still limited to the teacher's explanation and does not utilise learning media by the characteristics of students. This has an impact on the low motivation of students to learn, especially in Physics. This research aims to produce educational snake and ladders game products which integrate QR codes as an alternative physics learning media. The development model used is 4D. However, this research is limited to the 3D stage, mainly defining, designing, and developing. 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 educational aspect score was 11 with a percentage 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.

Keywords: *Learning motivation, Educational games, Snakes and ladders.*

A. INTRODUCTION

Enhanced self-development fundamentally originates from the realms of knowledge acquisition, the formation of appropriate attitudes, and the mastery of various scientific disciplines, as noted in the works (Asnita & Wayong, 2022; Puspitarini & Hanif, 2019). alongside Puspitarini and Hanif in 2019. The activities associated with learning are deeply intertwined with the processes of teaching, forming an integral, cohesive unit that cannot be separated from the overall learning experience, as highlighted (Asnita & Wayong, 2022). In contemporary educational settings, it has been observed that the learning dynamics tend to be predominantly student-centered, while the teaching methodologies are more often characterized by a teacher-dominated approach. The nature and quality of the interaction that transpires between students and teachers play a crucial role in determining the overall effectiveness and success of the learning process, a sentiment echoed (Napitupulu, 2019).

An educator must possess the capability to meticulously design the learning process in a manner that optimally supports student engagement, as this design has significant implications for the eventual learning outcomes achieved by students. The outcomes of student learning serve as measurable indicators of the quality and efficacy of the

educational processes implemented, a viewpoint supported by the research conducted (Sumardi et al., 2020). The learning process achieves a heightened level of effectiveness when students are positioned at the core of the educational experience, as articulated (Marpaung & Azzajjad, 2020) dan guru hanya menjadi fasilitator dan stimulator (Pradana, 2020). while the teacher's role transitions to that of a facilitator and stimulator of learning. Moreover, it is essential that the learning environment is structured in a way that allows students the necessary space and opportunities to construct and develop their own understanding of knowledge, as discussed (Chyta et al., 2019).

Physics, as a significant domain within the scientific landscape, is dedicated to the exploration and examination of various phenomena and occurrences that manifest within the universe, a notion clearly articulated (Harefa, 2019). The educational pursuit of understanding physics extends beyond the mere discovery of abstract ideas or theoretical concepts; it encompasses the practical application of these concepts in the context of everyday life scenarios. Nevertheless, students frequently encounter challenges when attempting to discern which specific concept should be applied in various physics-related problems, a difficulty highlighted (Körhasan & Gürel, 2019). Another common hurdle faced by students pertains to their mathematical competencies and the attitudes they possess towards mathematical problem-solving. Research conducted Sari et al (2018) indicates that, during the end-of-semester evaluations for physics conducted across three high schools in Surakarta City, a mere 40% of the students managed to achieve scores that surpassed the Minimum Passing Criteria, or KKM.

This statistic serves to illustrate the concerning reality that students' learning outcomes in physics remain relatively unsatisfactory and below expectations. Additionally, the current physics learning processes implemented in educational institutions continue to prioritize teacher-led explanations (Saleh, 2020), which, coupled with a noticeable lack of active participation from students and the immediate presentation of mathematical problems, contributes to a general decline in student motivation towards the study of physics. This decline in motivation is a significant concern, as evidenced by the findings (Budiarti & Jumadi, 2023; Sutarto et al., 2014). as well as Sutarto et al. in 2014. In fact, it has been established that the overall learning process tends to improve markedly when students exhibit a strong intrinsic motivation to learn. This assertion is supported (Puspitarini & Hanif, 2019).

Menurut Sardiman (2012) dalam Puspitarini & Hanif (2019), learning motivation represents the intrinsic driving force that compels students to actively engage in their learning endeavors, thereby ensuring that the educational process effectively meets its intended goals. The level of learning motivation present within students emerges as a pivotal factor that significantly influences the outcomes of their educational experiences, as noted (Yu et al., 2024). Students who demonstrate elevated levels of learning motivation typically exhibit a heightened enthusiasm and willingness to participate in the learning process, which correlates with improved comprehension and mastery of the material being studied. In addition to the intrinsic factors that may inspire motivation within students themselves, it is critical to recognize that this learning motivation can also be fostered and

enhanced through various stimuli and supportive elements present in the students' surrounding learning environment, a claim reinforced (Puspitarini & Hanif, 2019).

There exists a multitude of approaches that can be employed to augment and enhance the intrinsic motivation of students towards learning, one of the most notable methods being the strategic development of various learning strategies that facilitate educational engagement. Learning strategies, as defined in scholarly literature, encompass a diverse array of methods and media that are utilized throughout the educational process to foster understanding and retention of knowledge (Puspitarini & Hanif, 2019). Among the plethora of methods that can be effectively implemented within this framework is the innovative edutainment learning method, which serves as a pedagogical approach that artfully intertwines educational principles with entertainment elements (Purwanto, 2019). In simpler terms, the edutainment learning method is designed to cultivate a delightful and enjoyable learning experience, thereby making the educational journey not only informative but also engaging and pleasurable for students (Regitanurvikasari et al., 2022).

The edutainment learning paradigm can be effectively manifested through the incorporation of game-based learning strategies that leverage the inherent appeal of games to enhance educational experiences (Sari & Ahmad, 2022). *Game-based learning fundamentally involves the strategic integration of games within the educational framework to fulfill cognitive requirements and stimulate the motivational aspects of students' learning endeavors* (Alam, 2022; Calatrava et al., 2022; Malone, 1981). A prime example of an educational game that can be meticulously developed for this purpose is the classic snakes and ladders game, which is traditionally a board game that accommodates participation from two to four players, thereby fostering a collaborative learning environment (Ibam et al., 2018). The unique characteristic of this game lies in its visually engaging game board, which is adorned with vivid illustrations of snakes and ladders, effectively capturing the attention and interest of the players (Kholipah et al., 2020).

According to the comprehensive findings derived from an extensive literature review, the researcher has identified numerous scholarly investigations concentrating on the innovative development of snake and ladder games, which serve as effective learning mediums designed to facilitate and enhance the overall educational process for students. For instance Karimah et al (2014) successfully devised a traditional printed snakes and ladders game that specifically addresses the educational topic of vibrations and waves, while in a more recent study conducted Guterres et al (2018) a digital version of the snakes and ladders game was created to engage learners in the pressing subject matter of global warming. Furthermore, it is noteworthy, Permana et al (2024) also contributed to this body of research by designing a digital snake and ladder game, yet their focus was distinctly oriented towards utilizing this game as an effective medium for providing practice in solving physics problems, particularly emphasizing the crucial topics of mechanics and fluid dynamics.

The collective findings from these various studies strongly indicate that the implementation of the developed snake and ladder game has the potential to significantly bolster students' motivation to learn and engage with the material presented to them. Nevertheless, it is important to highlight that the advancement of snake and ladder games

specifically tailored for physics educational materials remains relatively sparse and underexplored. In light of this observation, the researchers have expressed a keen interest in creating a novel snakes and ladders game that will function as an educational medium for teaching physics, with a primary emphasis on the increasingly relevant topic of renewable energy. This initiative is designed to yield physics learning resources that are in alignment with the evolving interests and specific needs of contemporary students. In contrast to certain prior investigations, the innovative design of this snake and ladder game will incorporate QR code technology, thereby enhancing the interactive and engaging aspects of the learning experience. Consequently, the primary focus of this research will be dedicated to the development of an educational snake and ladder game that is seamlessly integrated with QR codes, specifically targeting the instructional content related to renewable energy concepts. Moreover, the introduction and availability of this game are anticipated to foster an edutainment environment that not only captivates students' interest but also significantly improves their academic performance and learning outcomes in the discipline of physics

B. RESEARCH METHOD

This particular research endeavor is categorized under the broader umbrella of research and development (R&D), utilizing a comprehensive 4D development model, which encapsulates four distinct but interconnected stages: define, design, develop, and disseminate, as articulated (Thiagarajan et al., 1974). The initial stage, known as the define stage, is fundamentally concerned with the meticulous process of articulating a specific problem, which is accomplished through a thorough needs analysis, alongside the establishment of precise learning objectives and the execution of various analytical assessments. Progressing to the subsequent stage, referred to as the design stage, it is imperative to engage in the careful and systematic design of the educational product that is intended for development, ensuring that it aligns with the previously identified needs and objectives. Following this, the develop stage is characterized by the actual creation of the product, which must then undergo a rigorous phase of validation by experts in the field. Finally, the disseminate stage entails the strategic distribution of the finished product to educational institutions, including schools and teachers, thereby facilitating its practical application in educational settings. Nevertheless, it is crucial to note that this particular research project has only advanced to the development stage, specifically halting at the critical phase of expert evaluation.

In terms of the subjects participating in this study, the focus is narrowed down to a singular expert, who is identified as a lecturer affiliated with the Physics Education Department at Universitas Negeri Surakarta (UNS), specifically one who specializes in the instruction of courses related to Educational Physics Learning Media. The methodology employed for data collection in this research involves the utilization of a well-structured questionnaire, which is specifically designed to gather the validation results provided by the expert, encompassing three pivotal aspects: technical, educational, and aesthetic dimensions, as elaborated upon (Nurfadilah et al., 2021). in their 2021 study. Each aspect of validation is meticulously assessed based on a standardized 3-point rating scale, which categorizes the quality of the product as high quality (3), medium quality (2), or low quality (1), thus providing a nuanced evaluation framework. The construction of the questionnaire itself employs a closed-ended format, which facilitates ease of use for the experts, allowing them to efficiently indicate their responses by simply checking the relevant indicators. For

clarity and reference, the grid that outlines the expert validation instrument is conveniently presented in Table 1, providing a visual representation of the evaluation criteria employed in this research.

Table 1. Expert Validation Instrument Grid

No.	Aspect	Indicator
1	Technical	1. Product suitability for students' age
		2. Easy to use
		3. Adds enjoyment
		4. Language used is appropriate for students' age
		5. Clarity of game instructions
		6. Product materials are safe and durable
2	Educational	1. Alignment of materials with standards, objectives, and curriculum
		2. Alignment with developmental stages
		3. Encouraging student learning activities
		4. Stimulating students' thinking abilities
3	Aesthetic	1. Ergonomic shape
		2. Easy for students to carry
		3. Size compatibility
		4. Color combination used
		5. Font selection and font size

The outcomes derived from the expert validation process undergo a thorough examination that encompasses both qualitative and quantitative methodologies, thereby ensuring a comprehensive understanding of the findings. The qualitative assessment is primarily derived from the constructive critiques and insightful recommendations imparted by the experts, which are aimed at enhancing the overall quality and effectiveness of the media product in question. In parallel, the quantitative evaluation of the expert validation results involves a meticulous analysis of the numerical scores assigned by the experts, which are subsequently organized into distinct classifications that are clearly delineated and presented in Table 2 for ease of interpretation and reference. This dual approach of analysis not only enriches the understanding of the expert feedback but also facilitates a robust framework for the systematic improvement of the media product based on empirical data. (Widoyoko, 2011).

Table 2. Criteria for Validating Educational Games

Interval Score	Interval Score
$38,82 < \bar{x}$	Very good
$32,94 < \bar{x} \leq 38,82$	Good
$27,06 < \bar{x} \leq 32,94$	Fairly good
$21,18 < \bar{x} \leq 27,06$	Not good
$\bar{x} \leq 21,18$	Bad

Moreover, the computation of the percentage score attributed to expert validation was meticulously conducted utilizing the methodology delineated in equation 1, in which the variable i represents the specific percentage allocated to each distinct aspect being evaluated in the overall assessment framework.

$$i = \frac{\text{the average score of each aspects}}{\text{the gighest score ideal for each aspects}} \times 100\% \quad (1)$$

C. RESULTS AND DISCUSSION

In the initial phase, which is commonly referred to as the define stage, a comprehensive needs analysis alongside the meticulous specification of learning objectives is undertaken to ensure a structured approach to the educational initiative being developed. The needs analysis is particularly grounded in the empirical findings derived from an extensive literature review, which serves as a critical foundation for the subsequent design of the educational game that is intended to be developed. The outcomes of this thorough analysis reveal that, when examining three distinct high schools located within the urban confines of Surakarta City, and utilizing a sample population of 90 students from the XI MIPA class, the average motivation level for engaging with the subject of physics is categorically classified as either low or moderate, as identified (Sari et al., 2018). Such findings compellingly illustrate a concerning lack of interest exhibited by students when it comes to the study of physics. In order to effectively enhance the motivation for learning among students, it is proposed that the incorporation of innovative learning media can be beneficially employed throughout the physics instructional process. The methodology of game-based learning emerges as a promising and effective innovation within the realm of educational media that can be implemented successfully. By embracing the concept of learning through play, this approach has the potential to significantly augment students' active engagement, foster their creativity, and ultimately elevate their motivation to learn, as suggested (Tapingkae et al., 2020).

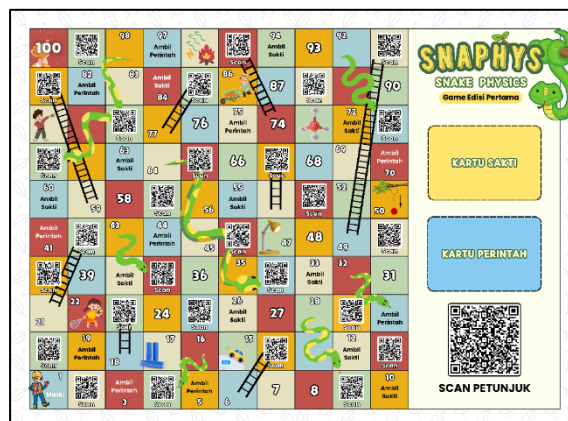
A thorough examination of the literature indicates that one particularly suitable game that can be developed in this context is the classic game of snakes and ladders. Several scholarly studies have demonstrated that the act of playing snakes and ladders can render the learning experience more enjoyable and engaging, thereby serving to stimulate students' motivation to delve deeper into the subject matter of physics, as evidenced (Guterres et al., 2018; Karimah et al., 2014; Permana et al., 2024). Consequently, within the framework of this research, a snake-and-ladder game will be meticulously created as a medium for facilitating the learning of physics, which will be seamlessly integrated with the cutting-edge technology of QR codes. It is anticipated that the game designed through this research endeavor will not only fulfill the identified educational needs but also effectively achieve the established learning objectives, thereby contributing to a more robust educational experience.

Moving on to the design stage, the physical snake and ladder game, which has been aptly named SnaPhys, was meticulously crafted in accordance with the insights gleaned from the prior analytical phase. This educational game has been thoughtfully designed with a game board that measures a precise 45 cm by 33 cm, and it consists of a total of 100 numbered squares, as well as 2 designated card squares, and is also equipped with QR codes that provide playing instructions for enhanced user experience. The SnaPhys game is conceptualized as a dynamic learning medium specifically intended for assessment purposes, which effectively means that it serves as a platform for practice questions that can be utilized in the educational setting. The questions presented within this innovative learning framework are delivered in a digital format via Google Forms, and the link to the Google Form will subsequently be transformed into a QR code to facilitate ease of access

and interaction. The game board itself is designed to be printed, with the aspiration that this tangible format will significantly boost student engagement and learning activities within the classroom environment. Moreover, the incorporation of QR code technology to seamlessly integrate questions into the gameplay experience is expected to not only streamline the process of recording student responses into a comprehensive database but also to enhance the digital literacy skills of the students engaged in this educational exercise.

The third stage in this comprehensive process is identified as the development stage, during which the actual creation of the physical snake and ladder game is executed, building upon the foundational design and incorporating product validation conducted by subject matter experts. The development of this educational game is carried out using the user-friendly Canva application, which has been selected due to its accessibility and the fact that it is free to utilize, making it an ideal choice for this endeavor. The design output produced consists of two distinct components, namely the game board itself and a set of cards designed for gameplay. The game card elements are categorized into two types: magic cards and command cards, each serving a unique purpose within the gameplay. The results stemming from the construction of the game board can be visually represented and are depicted in Figure 1, showcasing the culmination of the design and development efforts undertaken throughout this academic research.

Figure 1. Development Results of the SnaPhys Board



The game board is designed with a total of one hundred individual squares, beginning from the initial square marked with the number one and extending all the way to the final square numbered one hundred. In a manner similar to the traditional gameplay mechanics observed in the conventional snake and ladder game, the innovative SnaPhys game also incorporates vivid illustrations of snakes and ladders, which serve to enhance the visual appeal and thematic relevance of the game. Furthermore, there has been a deliberate effort to incorporate additional imagery that pertains specifically to the subject matter of renewable energy, thereby enriching the educational experience for the participants. A significant feature of this game is the evident incorporation of QR Codes, which have been strategically placed on various boxes throughout the board as well as within the accompanying game instructions. These QR Codes, when scanned, will redirect students to a Google Form link that contains a series of questions specifically related to the topic of renewable energy, thereby facilitating a deeper engagement with the material. The

questions posed within the context of this educational game encompass both conceptual inquiries and mathematical problems, effectively blending understanding with practical application.

Moreover, the SnaPhys game is further enhanced by the inclusion of both magic cards and command cards, which serve distinct purposes within the gameplay dynamics. The magic card is specifically designed to provide essential material information, acting as a supportive resource for students who may encounter challenges or difficulties when attempting to answer various questions posed during the game. On the other hand, command cards are utilized to issue specific instructions, such as advancing forward five steps or retreating three steps, thereby introducing an element of strategy and chance into the gameplay. Each type of card is characterized by unique base colors, which have been thoughtfully chosen to facilitate easy differentiation between the two categories. The outcomes and visual representations of the card development process can be observed in the illustrative Figures 2 and 3, which provide a comprehensive overview of the design and functionality of these components within the game framework.

Figure 2. Results of the Development of the Sakti Card. (a) Cover, (b) Content



(a)

(b)

Figure 3. Results of Command Card Development. (a) Cover, (b) Content



(a)

(b)

Furthermore, it is noteworthy that this particular game is accompanied by an array of playing implements that include essential components such as dice, a shaker for rolling, and various pieces that are designated for use by the players during the gameplay. The SnaPhys game is designed to accommodate a group of players, specifically allowing for participation

by between four and five individuals at a time, creating an engaging environment for all involved. In contrast to the developmental outcomes that were derived from the snakes and ladders game as analyzed Permana et al (2024) dan Guterres et al (2018), it is important to highlight that the developmental results associated with the SnaPhys snakes and ladders game are uniquely presented in a tangible printed format. This deliberate choice to utilize printed media is grounded in the assertion that such media can significantly enhance the learning experiences of students, thereby facilitating their educational activities in a direct and concrete manner, as suggested by the findings (Hermansyah et al., 2023). Furthermore, the developmental results pertaining to the snakes and ladders game as discussed Karimah et al (2014) are characterized by the inclusion of two distinct types of game cards, which are specifically categorized as question cards and answer cards for the players' use.

In stark contrast to this traditional format, the SnaPhys game innovatively integrates the use of QR Codes within its questioning system, thereby providing students with an interactive and modern approach to answering questions. Moreover, it is worth noting that students participating in the SnaPhys game will not be immediately presented with the correct answers, which necessitates that they engage in a process of perseverance and critical thinking until they arrive at the correct response. This approach is designed to promote a deeper understanding of the questions posed, thereby enhancing the educational value of the game for the students involved. Subsequently, a thorough expert validation process was conducted, which encompassed a comprehensive evaluation across three crucial dimensions: technical proficiency, educational relevance, and aesthetic appeal. The detailed results of this expert validation process can be systematically observed and analyzed in the data presented within Table 3.

Table 3. Expert Validation Results

No.	Aspect	Number of Questions	Number of Choices	Score	Max Score	Percentage (%)
1.	Technical	6	3	17	18	94,4
2.	Educational	4	3	11	12	91,6
3.	Aesthetic	5	3	13	15	86,6
Total		15		41	45	91,1

Table 3 presents a comprehensive depiction of the findings derived from the quantitative analysis concerning the product, which is based on the validation results provided by various experts in the field. In the assessment of the technical dimension, the product attained a score of 17, translating to an impressive percentage of 94.4%, while the educational dimension, which is equally significant, garnered a score of 11, resulting in a percentage of 91.6%, and finally, the aesthetic dimension achieved a score of 13, corresponding to a percentage of 86.6%. When one calculates the cumulative average score across all assessed dimensions, it yields an overall score of 41 with an average percentage of 91.1%, thereby categorizing the SnaPhys game firmly within the 'very good' category according to established evaluative criteria.

Furthermore, the qualitative analysis reveals insights derived from the critiques and constructive suggestions put forth by the experts, which include essential considerations such as the need for meticulous attention to the italicized formatting of certain terms, as well as the imperative to assess the quality of the paper material utilized and the safety of the card shapes to prevent any potential injuries to students during gameplay. A plethora of studies have underscored the notion that learning media predicated upon the traditional snakes and ladders game framework are not only appropriate for educational use but also effectively stimulate students' intrinsic motivation towards learning. Consequently, it follows that the SnaPhys game, which has been carefully designed and developed in accordance with these principles, is deemed highly appropriate for implementation within the physics learning environment of the classroom and is anticipated to significantly bolster students' enthusiasm and motivation to engage with the subject of physics.

D. CONCLUSION

In the course of this comprehensive research endeavor, a sophisticated educational media product designed specifically for teaching physics was meticulously developed, which is fundamentally based on the traditional educational game of snakes and ladders, and further enhanced through the innovative integration of QR codes that are strategically aligned with the curriculum centered around renewable energy concepts. Upon thorough examination and evaluation by subject matter experts, the validation outcomes revealed that in terms of technical attributes, the product garnered an impressive score of 17, translating to a remarkable percentage of 94.4%, while in the educational dimension, it achieved a commendable score of 11 with a notable percentage of 91.6%, and in the aesthetic evaluation, it secured a score of 13 accompanied by a percentage of 86.6%. Consequently, by aggregating these scores, an overall average score of 41 was calculated, which corresponds to an average percentage of 91.1%, thereby categorizing this innovative snakes and ladders game as exceptionally good and unequivocally suitable for implementation within the physics learning framework. This validation underscores the product's potential to significantly enhance the educational experience by providing an engaging and interactive method for students to explore and understand complex physics concepts through the lens of renewable energy topics.

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