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Game-based learning for nutrition literacy: Design and feasibility of an interactive snakes and ladders game in stunting-prone areas

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Abstract

Background: Nutrition education among elementary school children in stunting-prone areas remains limited and often relies on monotonous lecture-based approaches. Interactive learning strategies such as game-based education can enhance engagement, comprehension, and retention of health information. **Objective**: This study aimed to design, validate, and assess the feasibility of the interactive snakes and ladders game as a tool for promoting nutrition literacy among elementary school students. **Methods:** A Research and Development (R&D) approach adapted from the Borg and Gall model was employed in four phases: needs assessment, design and development, expert validation, and feasibility testing. Three experts evaluated the game using a structured validation form, while 60 students participated in classroom feasibility trials. Quantitative data were analyzed using descriptive statistics and the Content Validity Index (CVI), complemented by qualitative feedback from experts and users. **Results:** The overall CVI score of the game was 0.89, indicating high content validity. Expert feedback emphasized that the game's content, visuals, and language were relevant and age-appropriate. Feasibility testing showed strong positive responses from students—95% found the game enjoyable, 90% reported increased knowledge, and teachers rated its classroom practicality at 90%. Observations revealed high enthusiasm and cooperation during gameplay. **Conclusion:** The game proved to be a valid, feasible, and engaging educational tool that effectively integrates entertainment and learning to enhance children's nutrition literacy. Its low-cost and culturally relevant design makes it suitable for implementation in school-based health promotion programs, particularly in regions vulnerable to stunting.

Keywords: Game-based learning; nutrition literacy; snakes and ladders; stunting prevention; nutritional epidemiology.

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INTRODUCTION

Stunting in children in low-resource settings represents an important public health problem that hampers their growth and cognitive development. Conventional methods of nutrition education that generally involve lecturing and passive learning have also had limited success in such settings. Research indicates that children in these settings lack interest in traditional education methods and therefore do not retain the critical nutritional knowledge needed to improve their dietary behaviours [1,2] . This gap raises an urgent need for new educational approaches that can engage and empower these young learners [3,4].

Interactive, game-based learning methods are particularly attractive alternatives to such traditional teaching tools especially in nutrition education. Studies have shown that play as a technique boosts motivation and achievement in children, leading to significant behavioral change of dietary habits [5,6] and Baranowski et al. Games of such sort reinforce the concepts of nutrition and build a cooperative as well as competitive spirit, thus increasing students' interest when compared to traditional ways [7,8].

Active, play-based curriculum options have been identified as features of a promising alternative, and this is particularly the case when dealing with nutrition education. Children's engagement and retention for behaviour change in dietary intake can be meaningful when using playful methods [3–6]. For example, research has shown that useful games such as Snakes and Ladders can be incorporated in educational curriculum to add fun and impact [7,9]. These games may help to build and strengthen nutritional knowledge while developing a co-operative and competitive spirit which promotes the interest of students much more than traditional lesson [8,10]. The game designed as an interactive Snakes and Ladders educational tool, addresses the specific nutritional challenges faced by children in Indonesian primary schools. This initiative is relevant given the cultural adaptability and cost-effectiveness of the Snakes and Ladders format, making it accessible for widespread implementation. Previous research has shown that similar game-based interventions can significantly improve knowledge about dietary practices and increase interest in nutrition among young learners. Additionally, studies focusing on the development of educational games highlight their potential to facilitate learning in a fun and dynamic manner, directly addressing the needs of learners in low-resource contexts [5,11].

METHODS

Study design and setting

This study employed a Research and Development (R&D) design adapted from Borg and Gall (1983) and modified to suit educational media innovation. The R&D approach was selected because it enables systematic product development, expert validation, and limited field testing before widespread application. The study followed four main phases: (1) needs assessment, (2) design and development, (3) expert validation, and (4) feasibility testing. The study was conducted in two public elementary schools located in stunting-prone areas of Jambi City, Indonesia. These schools were selected purposively based on local health data indicating a high prevalence of stunting and limited exposure to nutrition education interventions.

Population, samples and sampling

Participants included 60 students (grades 4 and 5, aged 9–11 years) and three expert validators: a public health nutritionist, an educational media specialist, and an elementary school teacher. Inclusion criteria for student participants were: (a) enrolled

in grades 4–5, (b) able to follow written and verbal instructions, and (c) parental consent to participate.

Instruments and criteria

Four instruments were employed in this study to support data collection at different stages of the development process. The Needs Assessment Form was used during the initial phase to gather information from teachers and students through interviews and classroom observations, aiming to identify learning preferences and gaps in existing nutrition education methods. The Expert Validation Sheet consisted of 20 items distributed across four domains content, design, clarity, and suitability and was used by three expert validators to assess the relevance and quality of the game. The Observation Checklist was applied during the feasibility testing phase to systematically document students' engagement, enthusiasm, cooperation, and comprehension while playing the game. Lastly, the User Feedback Questionnaire, comprising 10 items rated on a five-point Likert scale, was used to measure students' satisfaction and perceived usefulness of the "Aku Anak Sehat" game as a learning tool.

Procedure and data collection

The development process was implemented in four structured phases following the Research and Development framework. The first phase, needs assessment, aimed to identify the requirements and preferences of both teachers and students related to nutrition education tools. Data were collected through interviews, classroom observations, and short questionnaires to explore existing learning challenges and expectations. The findings from this phase were used to determine the game's content focus, emphasizing key themes such as balanced diet, hygiene practices, and physical activity that are relevant to stunting prevention among children.

The second phase, design and development, involved creating an interactive board game entitled "Aku Anak Sehat" (I Am a Healthy Child) based on insights from the needs assessment. The design integrated nutrition education messages into a classic snakes and ladders format consisting of 36 squares, each containing positive or negative health prompts such as "Eat vegetables every day move up two steps" or "Skip breakfast move down three steps." To enhance engagement, nutrition quiz cards were added as part of the gameplay. The visual design used bright, child-friendly colors and illustrations to appeal to elementary students. The prototype was printed in a 200 × 200 cm format and designed for group play involving four to six children per session.

The third phase, expert validation, aimed to assess the quality and appropriateness of the developed game. Three experts specializing in nutrition, educational media, and elementary education—evaluated the prototype in terms of content accuracy, instructional clarity, visual appeal, and age suitability. Each aspect was rated on a four-point Likert scale ranging from 1 (not relevant) to 4 (highly relevant). The overall validity of the instrument was calculated using the Content Validity Index (CVI), where a value equal to or greater than 0.80 was considered acceptable. Qualitative feedback from the experts was also reviewed and used to guide design revisions and improvements.

The fourth phase, feasibility testing, was conducted through a limited classroom trial to evaluate the practicality and user acceptance of the game. Students were grouped and supervised by their teachers while playing the game, and observations were made to document their engagement, interaction, cooperation, and comprehension of the embedded nutrition messages. Upon completing the session, students filled out a satisfaction questionnaire, while teachers provided feedback on

the practicality and classroom applicability of the game. The results from this phase informed the final adjustments to ensure the game's usability in real educational settings.

Statistical analysis

Quantitative data were analyzed using descriptive statistics (mean, percentage, and standard deviation). The CVI was calculated by dividing the number of items rated 3 or 4 by the total number of items, averaged across experts. Qualitative data from open-ended responses and field notes were analyzed thematically to identify strengths, weaknesses, and improvement areas in the game's design.

Ethical concideration

Ethical approval was obtained from the Health Research Ethics Committee, Faculty of Medicine and Health Science, Universitas Jambi (Approval No. 2546.UN21.8/PT.01.04/2025). Participation was voluntary, and written informed consent was obtained from parents or guardians. Students were informed that the activity was part of an educational study and could withdraw at any time without penalty. Confidentiality of all participants' information was maintained throughout the study.

RESULTS

The results describe the outcomes of the expert validation process and the feasibility testing among elementary school students. During the needs assessment phase, teachers and students reported that existing nutrition education methods were mostly limited to lectures and posters, which were considered monotonous and less interactive. Teachers emphasized the need for engaging, visually attractive learning tools that promote student participation. Students expressed enthusiasm for educational games that allow them to learn while playing. These findings guided the design of the "Aku Anak Sehat" snakes and ladders game.

In the expert validation phase, the game prototype was reviewed by three experts in the fields of nutrition, educational media, and elementary education. Evaluation covered four aspects—content, design, clarity, and suitability. The overall Content Validity Index (CVI) score was 0.89, indicating high validity (Table 1). The content aspect achieved the highest CVI score (0.92), confirming the relevance and accuracy of nutrition messages. The design aspect scored 0.87, reflecting that the visual appearance was appropriate and appealing for children. Clarity and suitability domains scored 0.86 each, showing that language and difficulty levels were appropriate for elementary students. Experts recommended improving font size and simplifying certain messages for better comprehension.

Table 1. Expert validation scores of the "*Aku Anak Sehat*" game prototype

Domain	Number of Items	Mean Rating (1–4)	CVI*	Interpretation
Content	6	3.68	0.92	Highly valid
Design	5	3.48	0.87	Valid
Clarity	5	3.44	0.86	Valid
Suitability	4	3.45	0.86	Valid
Total	20	3.51	0.89	Highly valid

Remarks: *CVI = Content Validity Index; calculated from three expert validators

The feasibility testing phase involved 60 students divided into groups of four to six, with teachers supervising the gameplay. Observations revealed that students showed high levels of excitement, collaboration, and understanding during the session. Teachers reported that the game increased engagement among less active students and was easy to integrate into class schedules. Quantitative analysis from the user feedback questionnaire showed that 95% of students found the game fun and easy to understand, and 90% reported learning new information about healthy eating and hygiene. Teachers gave an average practicality score of 90%, indicating that the game could be applied effectively in the classroom without additional materials (Table 2).

Table 2. Summary of student and teacher feedback on game feasibility (n = 60)

Evaluation Item	Respondents (%)	Interpretation
Game is fun and enjoyable	95	Very positive
Easy to understand instructions	93	Very positive
Increased knowledge about nutrition	90	Positive
Encouraged teamwork and participation	88	Positive
Suitable for classroom use (teacher assessment)	90	Very feasible

Figure 1. Final "*Aku Anak Sehat*" snakes and ladders game

The developed board game titled "*Aku Anak Sehat*" (I Am a Healthy Child) represents an innovative educational tool designed to promote nutrition literacy and healthy behavior among elementary school students. The snakes and ladders format was adapted to include health-related messages that reinforce daily hygiene and nutrition practices (Figure 1.). Each square on the board illustrates specific behaviors—positive actions such as eating vegetables, washing hands, and completing immunizations allow players to climb ladders, while negative behaviors like skipping breakfast, littering, or eating instant snacks cause them to slide down snakes. The colorful and child-friendly layout is intentionally designed to capture students' attention and make the learning process enjoyable.

The visual presentation of the board game emphasizes key public health messages, including balanced nutrition, sanitation, personal hygiene, clean water use, and disease prevention. By integrating these concepts into a playful environment, the game transforms abstract health information into concrete, memorable experiences. The use of familiar cultural elements such as snakes and ladders also increases engagement and comprehension. Overall, the game successfully combines entertainment and education, serving as a practical and low-cost intervention to enhance children's awareness and understanding of healthy lifestyle behaviors in stunting-prone communities.

DISCUSSION

The game "Aku Anak Sehat" own high enough in a content validity index (CVI) value of 0.89 was obtained, completed by a good content validity and educational relevance. The feasibility study also found that students were enthusiastic and successfully comprehended the nutrition messages communicated through game play. Moreover, teachers considered the game highly feasible with 90% reporting that it was easy to implement in classroom. Taken together, those findings demonstrate that game-based learning is a promising strategy to improve students' interests and knowledge of nutrition education, especially in stunted-setting contexts [5,12]. Given the increasing demand for new educational media in those contexts, we propose that interactivity and game involvement can be instrumental tools to help children develop healthier dietary behaviors in their everyday lives [13].

Previous research supports these findings. For example, Prowse and Carsley (2021) performed an umbrella review that revealed digital interventions with a gaming component have the potential to positively influence children's knowledge and attitudes towards healthy eating [14]. Nevertheless, there is evidence that although knowledge and attitudes increased, the change in behaviour su ch as dietary intake was not always reflected. Similarly, García et al. (2025) focused on the use of serious games for environmental education instead of nutrition, showing little relation to nutrition behavior [15]. In contrast, Limone et al. (2022) concluded that serious games could develop engaging learning contexts, wherein the level of knowledge and eating behaviors is raised, which are very close to this study's aims [16]. These combined lessons support the contention that interactive, game-based learning has potential to provide engaging learning tools for young learners and promote compelling educational experiences even though direct evidence associating these with stunting prevention is limited [17].

This educational game is important, because it combines competition, entertainment and education which means that children learn through play. This child-led format takes advantage of kids' inherent urge to play and encourages them to learn through activity rather than passive listening. It fosters understanding and retention

of the nutritional content which are essential in achieving sustainable behavior change. Models of active learning such as this are particularly useful in low-resource environments, where children may learn better by participation and physical activity than they do from using lecture-based instruction [18].

The implications of such educational innovation go beyond the classroom and are congruent with wider health promotion interventions in education. It's a valuable game in the hands of facilitators and teacher, school health cadres, community health workers It is a great tool for nutrition education that increases the motivation and participation from students. Inclusion of this game in a school health program may increase participation and consolidate healthy behaviour among students. Properly designed, interactive educational media can contribute to public health goals by providing children with necessary knowledge and practical skills for making healthy dietary choices hence ultimately combating the age-old issue of stunting and improving child welfare in general [19,20].

Despite the good results, few strengths and limitations should be considered for future utilization and scalability of the "Aku Anak Sehat" game. While one of its big advantages is the simplicity with which it can be made, and that it's widely culturally applicable to the Indonesian setting. The game effectively integrates behavioral messaging with visual reinforcement that allows children to receive message points and to learn about nutrition concepts during play. By getting learners to actively participate in a fun and competitive way, it promotes active learning and retention even more than theory teaching only [21]. The existence of different methods to choose from can also sustain the children's interest, as well as enhance memory retention among them, in line with earlier studies which underlined the importance of interactive learning environments for sustaining motivation and improving performance [22].

However, several constraints should be recognized. Study limitations (VIII) The limited number of respondents (60 students) may limit the generalizability of the results for larger samples such as populations [23]. Furthermore, lack of long-term follow-up with pretest and posttest data will not allow for understanding if gains in knowledge and engagement translate into a sustained change at the level of behavior. The regional nature of the study in Jambi also limits generalisation to areas with different cultural or socioeconomic settings. These constraints emphasize that further studies with larger and more varied sample of subjects are required to confirm the game-based nutrition education effectiveness in scale [24].

Subsequent research games should overcome these limitations by employing quasi-experimental designs and larger sample sizes to more accurately estimate effects on nutrition knowledge, attitudes and behaviour in varying contexts. To increase the generalizability of the findings and analysis across cultural contexts [25], an increase in participant sample will be required. Incorporating digital tools (mobile apps or augmented reality) may also make for a more dynamic and user-friendly educational experience as previous research has suggested that technology-supported learning is linked with better engagement and retention [26]. Furthermore, longitudinal studies are needed to examine the long-term impact of the game on children's dietary behaviors and nutrition status. Interdisciplinary research, including education, health and community sectors collaborating on nutrition education tools is needed in order to guarantee their successful incorporation into multicomponent school-based health promotion programs. Such a collaboration can improve the global attempts to prevent stunting and children's overall health [27].

CONCLUSIONS

The result of this study shows that the interactive snakes and ladders game "Aku Anak Sehat" is a valid, feasible, and attractive educational measures for increasing nutrition literacy in elementary students in stunting risk program area. The interactive nature between play, competition and educational content of the game engaged students' attention and helped to improve their sensitization towards healthy dietary practices. Teachers found the tool pragmatic and convenient to use in classrooms, suggesting its potential for inclusion within larger school-based health initiatives. Although a small sample of teachers and geographic area were sampled in this study which requires cautious interpretation, the results broadly support show that game-based methodology may be a novel and culturally appropriate approach to improve nutrition education. Its long-term effects and potential for adaptation to other settings should be investigated further, with a view to sustainable improvements to child health and stunting prevention.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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DECLARATION OF ARTIFICIAL INTELLIGENCE USE

This study utilized artificial intelligence (AI) tools during the manuscript preparation process. Specifically, ChatGPT (OpenAI, USA) was employed to assist with language refinement, including improving grammar, sentence structure, and readability of the manuscript, as well as for outline organization. Additionally, Canva Pro (Canva Pty Ltd, Australia) was used for visualization support, including the design enhancement of illustrative figures. We confirm that all AI-assisted processes were critically reviewed by the authors to ensure the integrity, accuracy, and reliability of the final content. The final decisions, interpretations, and conclusions presented in this article were made solely by the author.

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