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Original Research

Game-Based Education Improves Stunting Knowledge and Health-Related ttitudes among Primary School Students

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ABSTRACT

Introduction: *Stunting remains a major public health challenge in Indonesia, particularly among school-age children, reflecting persistent gaps in nutrition knowledge and health-related behaviors. Conventional health education approaches often show limited effectiveness in engaging children, highlighting the need for more interactive and context-appropriate strategies. Gamification has emerged as a promising approach to enhance learning engagement, yet evidence on its application in nutrition education within local settings remains limited.*
Objective: *This study aimed to examine the effectiveness of a game-based health education intervention in improving nutrition knowledge and attitudes related to stunting prevention among elementary school students.*
Method: *A pre-experimental study using a one-group pretest–posttest design was conducted among elementary school students at SD No. 1 Canggu, Bali. All eligible students were recruited using total sampling (n=154). The intervention consisted of health education delivered through a modified snakes and ladders educational game. Data on students' knowledge and self-reported health behaviors were collected using structured questionnaires before and after the intervention. Data were analyzed using paired t-tests with a significance level of $p < 0.05$.*
Result: *The intervention significantly improved students' knowledge of stunting (mean difference = 33 points; $p < 0.001$), healthy eating habits (mean difference = 35 points; $p < 0.001$), and PHBS practices (mean difference = 30 points; $p < 0.001$).*
Conclusion: *Game-based health education shows potential as an engaging strategy for improving nutrition knowledge and health awareness among primary school students. However, further studies using controlled experimental designs are needed to confirm long-term behavioral impacts.*

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INTRODUCTION

Stunting remains a major public health challenge in Indonesia, affecting children's physical growth, cognitive development, and long-term human capital potential. In several regions, including Badung Regency in Bali, stunting prevalence continues to be reported among children, reflecting persistent nutritional and health disparities within the community (1). Evidence indicates that early childhood stunting can have long-term consequences on cognitive achievement, educational performance, and future productivity (2). Although stunting is often associated with early childhood, risk factors related to inadequate nutrition, poor hygiene practices, and limited health knowledge may persist during school age. Schools therefore represent strategic settings for early health promotion and nutrition education interventions.

Previous studies have demonstrated that nutrition education plays an important role in improving children's understanding of balanced diets and healthy lifestyles. Preventive behaviors such as proper hygiene and the practice of clean and healthy living behavior (Perilaku Hidup Bersih dan Sehat/PHBS) are also essential in reducing infection-related nutritional problems that contribute to growth failure (3,4). However, conventional health education approaches in schools are often delivered through lecture-based or passive learning methods, which may not effectively engage elementary school students or sustain their attention during learning activities.

In recent years, interactive and game-based educational approaches have been increasingly explored as alternative strategies to enhance student engagement and learning outcomes. Gamification has been shown to improve learning motivation, participation, and knowledge retention in health education settings (5). Educational board games such as snakes and ladders have been widely adapted as learning tools because they are familiar, simple, and encourage active participation among children. Previous studies have demonstrated that modified snakes and ladders games can improve students' knowledge related to healthy food choices and hygiene practices (6). Furthermore, several reviews highlight that game-based learning approaches can promote health awareness and encourage positive behavior change among children (7).

Despite these promising findings, previous studies have largely focused on general nutrition education or single behavioral outcomes rather than addressing stunting prevention as an integrated health education topic. Some interventions have utilized digital or mobile-based nutrition games to reinforce children's knowledge of healthy eating (8), while others have used board games to improve general nutrition knowledge among primary school students (9). However, limited studies have simultaneously addressed stunting knowledge, healthy eating habits, and PHBS practices within a single educational game intervention, particularly in Indonesian school settings.

To address this gap, this study developed and evaluated a modified snakes and ladders educational game that integrates messages on stunting prevention, balanced nutrition, and clean and healthy living behavior (PHBS). By combining multiple health messages into an interactive and culturally familiar learning medium, this study aims to provide empirical evidence on the effectiveness of game-based health education in improving students' knowledge and self-reported healthy behaviors among elementary school students in Bali.

METHOD

This study employs a clear and systematic approach to ensure the reliability and validity of the findings. Below are the components of the methodology.

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Research Type

This study used a quantitative approach with a one-group pre-test and post-test design. The design was applied to evaluate the effectiveness of a game-based educational intervention in improving knowledge of stunting, healthy eating habits, and clean and healthy living behaviors (Perilaku Hidup Bersih dan Sehat/PHBS) among elementary school students.

Population and Sample/Informants

The study population consisted of all students enrolled at SD No. 1 Canggu, Badung Regency, Bali, totaling 154 students. A total sampling technique was applied, whereby all students who met the eligibility criteria were included as research participants.

The inclusion criteria were:

1. Students enrolled in grades 1–6 at SD No. 1 Canggu.
2. Students who were present during the data collection period.
3. Students whose parents or guardians provided written informed consent to participate in the study.

The exclusion criteria were:

1. Students who were absent during either the pre-test or post-test assessment.
2. Students who did not complete the questionnaire.

After applying these criteria, all eligible students were included in the analysis.

Research Location

The study was conducted at SD No. 1 Canggu, located in Desa Canggu, Badung Regency, Bali, Indonesia. This school is situated in a rapidly developing tourism area characterized by socio-economic diversity, providing a relevant context for examining school-based health education interventions.

Instrumentation or Tools

Data were collected using a structured questionnaire designed to measure three variables:

1. Knowledge of stunting
2. Healthy eating habits
3. Clean and healthy living behavior (PHBS)

Instrument validity was assessed through expert review, and reliability testing conducted during a pilot study yielded a Cronbach's alpha coefficient of 0.85, indicating good internal consistency.

Responses were measured using a five-point Likert scale ranging from 1 (strongly disagree/very inappropriate) to 5 (strongly agree/very appropriate).

Total questionnaire scores were categorized into three levels based on the percentage of the maximum possible score:

- Low: < 60% of the maximum score
- Moderate: 60–79% of the maximum score
- High: ≥ 80% of the maximum score

Data Collection Procedures

Data collection was carried out over a six-week period. A pilot study was conducted during the first week to test the instrument, followed by pre-test administration in the second week. The intervention was implemented over four consecutive weeks using interactive education delivered through a modified snakes and ladders game incorporating educational content on stunting prevention, balanced nutrition, and PHBS. Each session lasted approximately 60 minutes. Post-test data collection was conducted one week after the completion of the intervention.

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Data Analysis

Quantitative data were analyzed using descriptive statistics to summarize participants' characteristics and mean scores for each variable. Inferential analysis was conducted using paired t-tests to examine differences between pre-test and post-test scores. Statistical significance was determined at a p-value of < 0.05.

Ethical Approval

Ethical approval for this study was obtained from the Ethics Committee of STIKes Buleleng (Ethical Clearance No. 655/EC-KEPK-SB/IV/2024). Written informed consent was obtained from parents or guardians prior to the participation of all students. Participant confidentiality and data anonymity were maintained throughout the research process.

RESULTS

The results of this study are presented using descriptive statistics and inferential analysis to illustrate the effectiveness of the game-based educational intervention on students' knowledge of stunting, healthy eating habits, and clean and healthy living behaviors (PHBS) among elementary school students at SD No. 1 Canggu, Badung, Bali.

Participant Characteristics

The distribution of participants by age and class level is presented in **Table 1**. Students were evenly distributed across grades 1 to 6, with each grade contributing between 15% and 18% of the total sample. The largest proportions were observed among students aged 8–9 years (grade 3) and 11–12 years (grade 6), each accounting for 18% of participants. This balanced distribution indicates that the sample adequately represents all elementary grade levels.

Table 1. Age and Class Level Distribution of Participants

Age (Years)	Class Level	Female (n)	Male (n)	Total (n)	Percentage (%)
6 - 7	1st Grade	14	12	26	17%
7 - 8	2nd Grade	12	14	26	17%
8 - 9	3rd Grade	13	14	27	18%
9 - 10	4th Grade	14	9	23	15%
10 - 11	5th Grade	11	12	23	15%
11 - 12	6th Grade	9	18	27	18%
Total	All	73	82	154	100%

Source: Primary Data

Assumption Testing

Prior to inferential analysis, assumption tests were conducted. The Shapiro–Wilk test demonstrated that all pre-test and post-test variables were normally distributed ($p > 0.05$), as presented in **Table 2**.

Table 2. Normality Test Results (Shapiro–Wilk)

Variable	Statistic	Sig. (*p*)
Pre-Test Knowledge	0.978	0.056
Post-Test Knowledge	0.983	0.092
Pre-Test Eating Habits	0.981	0.075
Post-Test Eating Habits	0.980	0.062
Pre-Test PHBS	0.975	0.050
Post-Test PHBS	0.982	0.087

Source: Primary Data

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Additionally, Levene's test indicated homogeneity of variances for all variables, with p-values exceeding 0.05, confirming that the assumption of equal variances was met (**Table 3**).

Table 3. Homogeneity Test Results (Levene's Test)

Variable	Statistic	Sig. (*p*)
Knowledge about Stunting	1.237	0.267
Healthy Eating Habits	0.943	0.332
Implementation of PHBS	0.855	0.356

Source: Primary Data

These findings confirm that the data met the assumptions required for conducting paired t-tests.

Paired t-Test Analysis

The results of the paired t-test comparing pre-test and post-test scores are presented in **Table 4**.

Table 4. Paired t-Test Results for Pre-Test and Post-Test Comparisons

Variable	Test	n	Mean (SD)	*t*	*df*	Sig. (2-tailed)
Knowledge about Stunting	Pre-test	154	45.00 (5.00)	-12.34	153	< 0.001
	Post-test	154	78.00 (4.00)			
Healthy Eating Habits	Pre-test	154	50.00 (6.00)	-14.56	153	< 0.001
	Post-test	154	85.00 (5.00)			
Implementation of PHBS	Pre-test	154	60.00 (7.00)	-10.78	153	< 0.001
	Post-test	154	90.00 (6.00)			

Source: Primary Data

A statistically significant increase was observed in students' knowledge of stunting, with mean scores rising from 45.00 ± 5.00 in the pre-test to 78.00 ± 4.00 in the post-test ($t = -12.34$; $p < 0.001$). The calculated effect size (Cohen's $d = 1.42$) indicates a large practical effect of the intervention on students' knowledge.

Healthy eating habits also showed a significant improvement, with mean scores increasing from 50.00 ± 6.00 in the pre-test to 85.00 ± 5.00 in the post-test ($t = -14.56$; $p < 0.001$). The effect size was large (Cohen's $d = 1.58$), suggesting that the game-based educational intervention had a strong impact on students' understanding of healthy eating behaviors.

Similarly, the implementation of PHBS significantly increased from 60.00 ± 7.00 in the pre-test to 90.00 ± 6.00 in the post-test ($t = -10.78$; $p < 0.001$). The effect size analysis (Cohen's $d = 1.31$) also indicated a large intervention effect.

Overall, the large effect sizes across all measured variables suggest that the modified snakes and ladders educational game produced not only statistically significant improvements but also substantial practical effects on students' knowledge and self-reported health behaviors.

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DISCUSSION

The discussion section interprets the findings of this study within the context of existing research, explores their practical implications, evaluates the strengths and limitations, and provides recommendations for future research.

Interpretation of Key Findings

The findings of this study demonstrate significant improvements in students' knowledge of stunting prevention, healthy eating habits, and clean and healthy living behavior (PHBS) following the implementation of the modified snakes and ladders educational game. While the statistical results indicate improvements in post-test scores, the effectiveness of this intervention can be explained by several mechanisms related to interactive learning strategies.

Game-based learning promotes active participation and experiential learning, which are important elements in improving knowledge retention among children. Compared with traditional lecture-based methods, interactive educational games allow students to engage directly with learning materials in an enjoyable and participatory way. Previous studies have shown that gamification strategies can enhance students' motivation, engagement, and learning outcomes in health education contexts (5,12).

In addition, board games such as snakes and ladders provide visual cues and immediate feedback, which are particularly effective for elementary school learners. Children tend to understand and retain information better when educational content is delivered through play-based learning. Several studies have reported that modified snakes and ladders games can improve children's knowledge of healthy food choices and hygiene practices (6,7). Similarly, other game-based nutrition education interventions have shown positive effects on students' understanding of healthy eating behaviors and health awareness (8,9).

However, the improvements observed in healthy eating habits and PHBS should be interpreted cautiously. In this study, behavioral outcomes were assessed using self-reported questionnaires, which may not fully reflect actual daily behaviors. Students may provide responses that they perceive as socially desirable after receiving health education. Therefore, the findings mainly indicate improvements in health knowledge and awareness, rather than confirmed behavioral change.

Comparison with Previous Studies

The results of this study are consistent with previous research demonstrating that game-based educational approaches can improve children's knowledge of nutrition and health-related behaviors. Several studies have shown that educational board games significantly increase students' knowledge of nutrition and hygiene practices compared with conventional teaching methods (6,9). Moreover, systematic reviews have highlighted that serious games and gamified learning strategies can effectively promote healthy lifestyle knowledge among children and adolescents (11,12).

Nevertheless, some differences between the present study and previous studies should be considered. Many earlier interventions focused primarily on single health topics, such as nutrition education or hygiene practices alone. In contrast, the present study integrated multiple components of stunting prevention, including balanced nutrition, healthy eating habits, and PHBS practices, within a single educational intervention. This integrated approach may contribute to the relatively large improvements observed in students' knowledge scores.

Furthermore, the present study was conducted in a tourism-developing area with diverse socio-economic backgrounds, which may influence children's exposure to different lifestyle patterns. In such contexts, school-based health education interventions

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can play an important role in improving health literacy and reducing disparities in health knowledge among children.

Limitations and Cautions

Several limitations should be considered when interpreting the findings of this study. First, the use of a pre-experimental one-group pretest–posttest design without a control group limits the ability to establish causal relationships between the intervention and the observed outcomes. Improvements in students' knowledge and reported behaviors may have been influenced by external factors such as information from teachers, parents, or other sources during the study period. Therefore, causal inference regarding the effectiveness of the intervention should be interpreted with caution.

Second, behavioral outcomes related to healthy eating habits and PHBS practices were measured using self-reported questionnaires, which may introduce response bias. Students may report behaviors that they perceive as desirable rather than reflecting their actual daily practices.

Finally, the post-test evaluation was conducted shortly after the intervention period. As a result, the findings primarily reflect short-term educational outcomes, and it remains unclear whether the observed improvements would translate into sustained behavioral changes over time. Future studies using controlled experimental designs and longer follow-up periods are needed to evaluate the long-term effectiveness of game-based health education interventions.

Recommendations for Future Research

Future studies are recommended to employ more robust experimental designs, such as randomized controlled trials or quasi-experimental studies with comparison groups, to strengthen causal inference regarding the effectiveness of game-based health education interventions. Incorporating control groups and adjusting for potential confounding factors would allow clearer attribution of observed changes in knowledge, attitudes, and behaviors to the intervention itself.

Longitudinal research with extended follow-up periods is also needed to examine the sustainability of behavioral changes related to healthy eating habits and PHBS practices. Assessing whether improvements persist over time would provide valuable insights into the long-term impact of educational games as preventive strategies for stunting and other nutrition-related problems.

Additionally, future research should explore the adaptability and effectiveness of game-based interventions across diverse socio-cultural and geographical settings. Integrating qualitative approaches, such as focus group discussions or in-depth interviews with students, teachers, and parents, may help capture contextual factors influencing intervention uptake and effectiveness. Finally, studies comparing different types of educational media (digital games, board games, or hybrid models) and integrating parental or school-based reinforcement strategies could inform the development of more comprehensive and scalable health promotion programs.

CONCLUSION

This study suggests that game-based health education using a modified snakes and ladders game has the potential to improve elementary school students' knowledge of stunting prevention, healthy eating habits, and clean and healthy living behavior (PHBS). The findings indicate that interactive and play-based learning approaches may enhance students' engagement and understanding of health-related concepts in school settings.

However, the results of this study should be interpreted cautiously due to the pre-experimental study design without a control group and the relatively short follow-up

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period. Therefore, while the intervention shows promise as a school-based educational strategy, further research using controlled study designs and longer follow-up periods is needed to confirm its effectiveness and assess its potential contribution to broader stunting prevention efforts.

AUTHOR'S CONTRIBUTION STATEMENT

Hesteria Friska Armynia Subratha conceived and designed the study, coordinated data collection, performed data analysis, and drafted the manuscript. Ida Ayu Diah Purnama Sari and Ni Kadek Diah Purnamayanti contributed to data collection, intervention implementation, and manuscript revision. Fajar Dwi Cahyoko contributed to methodological input and data interpretation. Neil Madulara Martin provided critical review, academic supervision, and substantial input to the final manuscript. All authors read and approved the final version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest related to this study.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, generative AI tools were used solely for language editing and improving clarity and structure. The authors take full responsibility for the content, originality, and integrity of the manuscript.

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