Influence of Educational Game-Based Learning on Knowledge and Ability in Nutritional Selection

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ABSTRACT

Background: *Malnutrition, particularly stunting, remains a global health issue that impedes child development and affects overall human quality. This study aimed to examine the effectiveness of "SPINERGY," an educational game-based health promotion media, in improving knowledge of stunting, balanced nutrition, and food selection skills among adolescents at SMPN 5 Batu.*
Method: *A quasi-experimental design with pre-test and post-test control groups was used, following a research and development (R&D) approach with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The study involved 116 students from grades VII to IX selected via proportional stratified random sampling. Data were collected using valid and reliable questionnaires (20 items each) to assess knowledge and food selection abilities before and after the intervention. Statistical analysis was conducted using the Mann-Whitney U Test.*
Result: *The findings showed a significant improvement in knowledge in the intervention group across all grades (VII, VIII, IX) compared to the control group ($p < 0,05$). For the food selection ability variable, a significant improvement was noted in grades VII ($p = 0,023$) and VIII ($p = 0,022$), while grade IX ($p = 0,112$) showed no significant change, likely due to a higher initial ability level. Developing SPINERGY into a digital format or dare game is recommended to make this medium more accessible, engaging for the younger generation, and relevant to current learning technology developments. Collaboration with educational institutions and health departments is also needed to strengthen the implementation and appeal of this game-based nutrition education program.*

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INTRODUCTION

Malnutrition, particularly stunting, remains a global health issue and continues to be a serious challenge, especially for infants and children under five years old. Stunting is not merely a problem of inhibited physical growth, but a complex condition indicating disturbances in brain development, which in turn can affect cognitive abilities and learning outcomes.(1) WHO defines stunting as a height below -2 SD due to poor nutrition or recurrent infections.(2) This condition not only impacts individuals, but also has longterm consequences for national development, as it can exacerbate poverty and hinder the potential of human resources.(1) Global stunting prevalence has fluctuated in recent years, reaching 21.9% (149 million children) in 2018, slightly decreasing in 2019, but rising again to 22% (149.2 million children) in 2020. Asia has the highest rate, especially South Asia, followed by Africa and Latin America. In 2022, the global prevalence slightly declined to 22.3% (148.1 million children), with Asia and Africa still dominating.(2–5) Indonesia ranks third in stunting prevalence in Southeast Asia, with an average of 36.4% between 2005–2017.(6)

The Basic Health Research (Riskesdas) data reports fluctuating stunting rates in Indonesia: 37.6% (2007), 35.8% (2010), 37.2% (2013), and 30.8% (2018), with an increase in children under two years from 28.0% (2013) to 29.9% (2018).(7) This number continued to decrease: 27.7% (2019), 24.4% (2021), 21.6% (2022), although the rate of decrease slowed to 21.5% (2023), which remains above the RPJMN (National Medium-Term Development Plan) 2020–2024 target of 14%.(8)(9) In East Java, the stunting rate dropped from 23.5% (2021) to 19.2% (2022) and 17.2% (2023), but the provincial target for stunting reduction has not yet been achieved.(8–10) Batu City has recorded significant fluctuations in stunting rates in recent years, with percentages in August as follows:

23.51% (2018), 25.4% (2019), 14.83% (2020), 13.8% (2021), 13.9% (2022), 12.78% (2023), and 11.21% (2024).(11) Although the trend shows a decline, continuous efforts are still needed to achieve the established targets.

Stunting, which arises due to inadequate nutrition or increased nutritional needs caused by illness, must be addressed from the first 1.000 days of life (1000 HPK).(8)(12) To tackle this, Presidential Regulation No. 42 of 2013 marked the beginning of the national program Gernas PPG (National Movement for the Acceleration of Nutrition Improvement)) initiated by the government, focusing on the 1000 HPK and integrating the stunting reduction targets into the RPJMN 2015–2019 and Iron Supplementary Programs (TTD) in 2017–2019.(13) This effort includes specific nutrition interventions targeting children and pregnant women, as well as sensitive nutrition interventions involving various sectors, including the provision of iron supplements (Tablet Tambah Darah/TTD) for adolescent girls.(8)(14)(15) Adolescents, particularly girls, are vulnerable to nutritional problems. WHO defines adolescents as those aged 10–19 years, while the Indonesian Ministry of Health Regulation No. 25 of 2014 defines the range as 10–18 years, and National Population and Family Planning Agency (BKKBN) categorizes the range as 10–24 years for unmarried individuals.(14)(16)(17) Nutritional imbalances during adolescence can result in prolonged health issues and hinder their preparedness to become healthy mothers.(18)

Balanced nutrition is a fundamental basis for optimal growth and overall health. However, studies show that adolescents' understanding and ability regarding balanced nutrition, particularly in stunting prevention, remain low. A study using a 14-item true/false questionnaire found that 53,5% of respondents had poor knowledge of balanced nutrition.(19) Another study in Kediri Regency involving adolescents aged 12–21 found that most adolescents had moderate nutritional selection ability (64,94%), while only 32,47% had good ability and 2,60% had poor ability.(20) Improving adolescents' knowledge and nutritional skills is vital to addressing stunting and various health disorders. Nutrition education can raise awareness among future parents about the importance of maternal and child health and help break the cycle of stunting.

The selection of Sumberbrantas as the research location was based on its high stunting prevalence in August 2024, which reached 16,55%, making it one of the villages with the highest stunting rates in Batu City. Its geographical location on the southwestern slope of Mount Arjuno presents accessibility challenges to health services and information, influencing local dietary habits and nutritional understanding, thereby increasing the risk of stunting in children.(21) Educational efforts are needed to enhance public understanding, especially among adolescents, of the role of balanced nutrition in stunting prevention. The success of educational programs heavily depends on the media used.(22) Strategies to improve adolescents' understanding and ability regarding stunting and balanced nutrition require interactive and educational health promotion media. Preliminary studies and needs assessments through interviews with the OSIS (Student Council) president and PMR (Youth Red Cross) at SMPN 6 Batu revealed that the currently used health promotion media, such as PowerPoint lectures, posters, leaflets, and animated videos, were perceived as unappealing and ineffective in capturing attention and increasing student participation. Previous studies consistently shows that educational methods emphasizing active student interaction yield more effective outcomes than passive learning methods, such as lectures or information delivered through leaflets. Game-based approaches have been shown to significantly improve nutrition literacy among adolescents, as evidenced by an increase in the average knowledge score from 5.4 to 8.0 among 28 students.(23)

In addition, the development of educational game media was found to be more engaging and effective in enhancing adolescents, understanding of the importance of physical activity compared to conventional learning methods. The educational game media was packaged in the form of a 2 × 1 m double-sided banner, cue cards measuring 11 × 9 cm containing a "TESABEN" segment with questions and answer keys, as well as interactive answer pins with a diameter of 5.8 inches.(24) The innovation of SPINERGY lies in combining visual aspects (board game and flashcards) with physical challenges for participants who fail to answer category-based questions, creating a fun yet meaningful learning experience. To date, no research has specifically designed an educational game to improve adolescents' understanding of stunting and balanced nutrition in Batu City, particularly in the Sumberbrantas area. Based on these findings, the development of the SPINERGY educational game is considered feasible as a learning tool that encourages active student participation and stimulates a richer learning experience compared to conventional approaches. Therefore, this study is designed to assess the effect of SPINERGY in improving knowledge of stunting, balanced nutrition, and nutritional selection ability among adolescents at SMPN 5 Batu.

METHOD

This study was designed as quantitative research with an experimental design, initially preceded by a

research and development (R&D) approach aimed at creating, measuring, and evaluating the impact of the SPINERGY educational game media on improving knowledge about stunting and balanced nutrition as well as nutritional selection ability among junior high school students. The experimental design used in this study was a quasi-experimental model with a two-group pre-test post-test with control group design, allowing for a clear comparison between the intervention group (which received the SPINERGY game) and the control group (which received no intervention). The development of this educational media followed the ADDIE model, a systematic solution to ensure that the resulting learning product is effective and tailored to the needs of its target audience. The previous development stage of SPINERGY media, conducted at SMPN 6 Batu, involved 48 student respondents consisting of 66.7% (32) female and 33.3% (16) male students. The results of the media feasibility questionnaire, completed by all respondents, showed that SPINERGY received a feasibility score of 80%, categorized as "very feasible" based on Arikunto's criteria.(25)

This finding indicates that SPINERGY can be implemented as an educational medium capable of increasing students' understanding of balanced nutrition and stunting prevention. The study was conducted at SMPN 5 Batu from June 2024 to January 2025, involving grade VII to IX students, totaling 163 students as the population. The research sample was determined using the proportionate stratified random sampling method, with balanced distribution between the intervention and control groups at each grade to obtain accurate and representative data. To determine the sample size, the study referred to Slovin's formula with a 5% margin of error. The final sample consisted of 116 students, including 46 seventh graders, 28 eighth graders, and 42 ninth graders. Each group was evenly divided into intervention and control subgroups to ensure the validity of the research results. The data collection instruments consisted of two types of questionnaires: a closed-ended pre-test and post-test questionnaire to assess knowledge of stunting and balanced nutrition, modified from Hamidah,(26) and a closed-ended questionnaire to assess nutritional selection ability, modified from Puspitadewi.(27) The stunting and balanced nutrition knowledge questionnaire contained 20 multiple-choice questions with four answer options, while the nutritional selection ability questionnaire consisted of 20 closed-ended statements. Instrument validation was tested using the Corrected Item Total Correlation through statistical software. The questionnaire was considered valid if the calculated r-value was greater than the r-table value with a probability value of less than 0,05. The reliability level of the instruments was measured using Cronbach's Alpha, with an alpha value above 0,6 indicating the instrument was reliable.

The validity and reliability testing of the research instruments, namely, the knowledge and nutritional selection ability questionnaires, was conducted on 26 out of 143 SMPN 5 Batu students who were not part of the main sample of 116 students. All 20 multiple-choice knowledge questions were declared valid with r-values ranging from 0.507 to 0.885, higher than the r-table value (0.388) and significance values below 0.05. The reliability test showed a Cronbach's Alpha of 0.813, which is greater than 0.60, categorizing the instrument as reliable with a good reliability level (0.8–1.0). Meanwhile, all 20 statements in the nutritional selection ability questionnaire completed by the 26 respondents were also deemed valid, with r-values ranging from 0.423 to 0.661, exceeding the r-table value (0.388) with a significance (2-tailed) of less than 0.05. The reliability test indicated a Cronbach's Alpha of 0.868, also exceeding 0.60, thus categorizing the instrument as reliable with a good reliability level (0.8–1.0).

This study utilized the SPINERGY educational game media as an interactive learning tool. The name SPINERGY combines the word "spin," symbolizing the dynamics of the game, and "-ergy," representing the energy and enthusiasm for knowledge exploration in the learning process. The main components of SPINERGY include the Nutrient Wheel, which determines the question categories (carbohydrates, proteins, vitamins, minerals, and fats); Nutrient Cards containing 30 visually engaging questions and answers; Physical Challenges consisting of 12 simple activities to maintain active player engagement; a Game Guide as an implementation manual; and a Handbook that teachers or facilitators can use to optimize SPINERGY as an interactive educational tool. The control and intervention groups were randomly selected using an online randomizer tool to ensure objective and unbiased group assignment.

The SPINERGY intervention was carried out by dividing the 58 students in the intervention group into several small teams, each consisting of 7 to 8 students, resulting in 8 groups. Each game session lasted a total of 45 minutes, distributed equally among the group members so that each student had approximately 5 to 6 minutes of interactive time, depending on the group size. The activities were conducted in a single large hall that accommodated all groups simultaneously in a conducive environment for active learning. The intervention was implemented once during the third week of December as

part of efforts to improve adolescent knowledge about stunting and balanced nutrition through an enjoyable and participatory educational game approach. Prior to the intervention, a pre-test was administered to measure baseline knowledge of stunting, balanced nutrition, and nutritional selection ability. The intervention group received learning through the SPINERGY educational game, while the control group received no intervention.

A post-test was administered 15 days after the intervention to evaluate changes in knowledge and nutritional selection skills between the intervention and control groups. Data analysis began with univariate analysis to present the frequency distribution and percentages of each variable and respondent characteristic. Subsequently, the Kolmogorov Smirnov and Shapiro-Wilk normality tests were conducted to determine the appropriate type of statistical test. Data were considered normally distributed if the post-test significance value was greater than 0.05. Since the data in this study were not normally distributed, the Mann-Whitney U test was used as an alternative to compare pre-test and post-test results across grades VII, VIII, and IX between the intervention and control groups. The ethical review process was completed, and the study was approved as ethically feasible by the Research Ethics Committee of Universitas Negeri Malang under the approval number No.11.12.05/UN32.14.2.8/LT/2024.

RESULT AND DISCUSSION

This study involved 116 respondents from grades VII, VIII, and IX who were actively enrolled at SMPN 5 Batu. Respondent characteristics analyzed included age and gender. The distribution of respondents is presented in the table below.

Based on the table above, most students in Grade VII were 13 years old (67.3%), in Grade VIII most were 14 years old (85.7%), and in Grade IX, the highest proportion was 15 years old (62%). In terms of gender, the number of male students was higher in Grade VII (52.1%) than in Grade IX (54.7%) and Grade VIII (46.4%). Meanwhile, the highest number of female students was also in Grade VII (47.9%), followed by Grade IX (45.3%) and Grade VIII (53.6%). A large-scale implementation was conducted on 116 students from SMPN 5 Batu across Grades VII, VIII, and IX. Each grade level was divided into two groups: an intervention group using the SPINERGY media and a control group with no intervention. The pre-test and post-test results for each group and grade level are shown in the following tables.

The knowledge level assessment categories according to Arikunto (2013) consist of three levels: good (76%–100%), fair (56%–75%), and poor (<56%). Based on Table 2, the intervention significantly improved students' knowledge. In the intervention group, the percentage of students with good knowledge increased in Grade VII from 21.7% (5 students) to 43.5% (10 students), in Grade VIII from 35.7% (5 students) to 92.9% (13 students), and in Grade IX from 66.7% (14 students) to 95.2% (20 students).

Meanwhile, the control group showed minimal increases, with Grade VIII rising from 14.3% to 28.6%, Grade VII from 4.3% to 8.7%, and Grade IX remaining stagnant. Additionally, the proportion of students with poor knowledge in the intervention group dropped to 0%, while in the control group it remained high, especially in Grade VII (60.9%) and Grade VIII (57.1%). These results show the intervention's effectiveness in improving students' knowledge compared to the control group.

Table 1. Frequency distribution based on respondent characteristics

Characteristics	Grade					
	VII		VIII		XI	
	n	%	n	%	n	%
Age						
12	13	28.2	0	0	0	0
13	31	67.3	3	10.7	0	0
14	1	2.25	24	85.7	16	38
15	1	2.25	1	3.6	26	62
Gender						
Male	24	52.1	13	46.4	23	54.7
Female	22	47.9	15	53.6	19	45.3
Total	46	100	28	100	42	100

Table 2. Frequency distribution based on knowledge

Variable	Intervention						Control					
	VII		VIII		IX		VII		VIII		IX	
	n	%	n	%	n	%	n	%	n	%	n	%
Pre-test												
Good	5	21.7	5	35.7	14	66.7	1	4.3	2	14.3	9	42.9
Fair	8	34.8	8	57.7	3	14.3	1	4.3	3	21.4	3	14.3
Poor	10	43.5	1	7.1	4	19	21	91.3	9	64.3	9	42.9
Post-test												
Good	10	43.5	13	92.9	20	95.2	2	8.7	4	28.6	9	42.9
Fair	13	56.5	1	7.1	1	4.8	7	30.4	2	14.3	6	28.6
Poor	0	0	0	0	0	0	14	60.9	8	57.1	6	28.6
Total	23	100	14	100	21	100	23	100	14	100	21	100

The categories of nutritional selection ability levels are determined based on calculations using the three-scale formula by Azwar (2012), namely high (score > 60), moderate (score 41–60), and low (score ≤ 40). According to Table 3, the intervention improved students' nutritional selection ability. In the intervention group, the "high" category slightly decreased in Grade VII from 43.5% to 39.1% and increased in Grade IX from 33.3% to 38.1%, while in Grade VIII it rose from 21.4% to 28.6%. The "moderate" category remained mostly stable, while the "low" category dropped to 0% in all grades from an initial 8.7% (2 students) in Grade VII. In the control group, the "high" category increased slightly, e.g., in Grade VII from 13% to 21.7%, and in Grade IX from 9,5% to 23.8%. The "moderate" category remained dominant, and the "low" category was not present from the start. These findings indicate that the intervention contributed more substantially to improving students' nutritional selection ability than in the control group.

Based on the Mann-Whitney U test results in Table 4, there was a significant difference in knowledge levels between the intervention and control groups in Grades VII, VIII, and IX. In Grade VII, a significant difference already existed before the intervention (pre-test = 0.000). After implementing the SPINERGY educational game, knowledge scores significantly improved (post-test = 0.000). The same occurred in Grade VIII (pre-test = 0.002; post-test = 0.001). In Grade IX, although there was no significant difference before the intervention (pre-test = 0.339), knowledge improved significantly afterward (post-test = 0.002). For nutritional selection ability, the results varied by grade. In Grade VII, the pre-test showed no significant difference (p = 0.222), but the post-test revealed a significant improvement (p = 0.023). Similarly, in Grade VIII, the pre-test was not significant (p = 0.159), but post-test results were (p = 0.022). In contrast, Grade IX already had a significant difference at pre-test (p = 0.000), indicating better initial ability in the intervention group. After intervention, despite an increase in mean score (58.86 vs. 56.00), the difference was not statistically significant (post-test = 0.112), indicating no significant impact of the intervention on nutritional selection ability in Grade IX

Based on Table 5, to determine differences in knowledge and nutritional selection ability between the intervention and control groups (across grades VII, VIII, and IX) at pre-test and post-test, the Mann-Whitney U test was performed. This non-parametric test was selected because the score data did not meet the assumption of normality. The difference between pre-test and post-test scoresshows that the average increase in knowledge and nutritional selection ability after the intervention was generally higher in the intervention group than in the control group at all grades, except in some cases such as nutritional selection ability in Grade IX, which slightly decreased in the intervention group. However, only the difference in nutritional selection ability in Grade IX was statistically significant (p = 0,001), while other variables had p-values above 0,05, indicating no significant difference. This suggests that the intervention did not consistently produce a statistically significant impact on improving knowledge and nutritional selection ability across all grade levels.

Table 3. Frequency distribution based on nutritional selection ability

Variable	Intervention						Control					
	VII		VIII		IX		VII		VIII		IX	
	n	%	n	%	n	%	n	%	n	%	n	%
Pre-test												
High	10	43.5	3	21.4	7	33.3	3	13	2	14.3	2	9.5
Moderate	11	47.8	11	78.6	14	66.7	20	87	12	85.7	19	90.5
Low	2	8.7	0	0	0	0	0	0	0	0	0	0
TOTAL	23	100	14	100	21	100	23	100	14	100	21	100
Post-test												
High	9	39.1	4	28.6	8	38.1	5	21.7	1	7.1	5	23.8
Moderate	14	60.9	10	71.4	13	61.9	18	78.3	13	92.9	16	76.2
Low	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	23	100	14	100	21	100	23	100	14	100	21	100

Table 4. Mann-Whitney U Test results for knowledge and nutritional selection ability between intervention and control groups (Grades VII, VIII, IX)

Class	Variable	N	Intervention		Control		P-value
			Mean	Min-Max	Mean	Min-Max	
	Knowledge						
	Pre-test	23	63.04	35-90	42.83	20-80	0.000
	Post-test	23	77.83	60-95	54.13	30-80	0.000
VII	**Nutritional selection Ability**						
	Pre-test	23	56.09	24-70	55.26	43-63	0.222
	Post-test	23	59.22	51-71	55.43	47-68	0.023
	Knowledge						
	Pre-test	14	74.64	40-95	39.64	10-85	0.002
	Post-test	14	90.36	65-100	58.57	25-95	0.001
VIII	**Nutritional selection Ability**						
	Pre-test	14	57.29	48-69	55.21	45-75	0.159
	Post-test	14	58.43	50-77	53.14	47-62	0.022
	Knowledge						
	Pre-test	21	77.62	50-90	65.00	15-95	0.339
	Post-test	21	88.81	75-95	69.29	30-95	0.002
IX	**Nutritional selection Ability**						
	Pre-test	21	60.52	53-73	53.05	43-68	0.000
	Post-test	21	58.86	49-69	56.00	46-66	0.112

Table 5. Pre-test and post-test differences in knowledge and nutritional selection ability in intervention and control groups (grades VII, VIII, IX)

Class	Variable	N	Post-test and Pre-test Mean		P-value
			Intervention	Control	
VII	Knowledge	46	14.79	11.3	0.298
	Nutritional selection Ability	46	3.13	0.17	0.620
VIII	Knowledge	28	15.72	18.93	0.401
	Nutritional selection Ability	28	1.14	-2.07	0.476
IX	Knowledge	42	11.19	4.29	0.058
	Nutritional selection Ability	42	-1.66	2.95	0.001

Differences in knowledge levels in grades VII, VIII, and IX

The SPINERGY educational game significantly improved students' knowledge, as shown in Tables 2 and 4, where the intervention group experienced a greater increase in the number of students with good knowledge compared to the control group, which showed only minor changes. The analysis also indicates a statistically significant difference between the two groups before and after the intervention. However, the pre-test and post-test difference test results shown in Table 5 indicate that although the average knowledge increase after the intervention was generally higher in the intervention group than in the control group across all grades, not all differences were statistically significant. Further analysis in Table 4 shows that the SPINERGY educational game was effective in increasing students' knowledge of balanced nutrition and stunting prevention across grade levels, with the greatest impact in Grade VIII, followed by Grade VII, and lastly Grade IX. However, there were significant differences in students' baseline knowledge prior to the intervention. In Grades VII and VIII, differences between the intervention and control groups were already apparent in the pre-test, indicating variations in baseline knowledge levels among students in both groups. This aligns with the findings of Payung et al., which indicated that students' initial knowledge may vary and significantly affect learning outcomes.(28)

The increase in knowledge following the intervention confirms the significance of the differences between the two groups. The data indicates that students who received the intervention through the educational game showed a greater increase in knowledge than those who did not. This is evidenced by the post-test results, where the p-value remained significant in Grade VII, was also significant in Grade VIII, and became significant in Grade IX after being non-significant in the pre-test. This reinforces that game-based approaches can be an effective strategy to enhance students' understanding of the material being taught. However, the impact of the intervention is not solely influenced by the game method used, but also by students' baseline knowledge before the intervention. Further analysis shows that students with higher prior knowledge tend to have better understanding compared to those with lower prior knowledge.(28) These results also suggest that game-based interventions have a substantial impact on improving knowledge in the intervention group, while increases in the control group were not significant. The difference in knowledge gains may be attributed to several factors, such as the effectiveness of game-based interventions in facilitating active learning, as well as differences in teaching strategies received by students.(29) On the other hand, in Grade IX, there was no significant difference between the intervention and control groups in the pre-test, indicating that students had relatively homogeneous baseline knowledge. This contrasts with Grades VII and VIII, where differences between groups were already evident from the start. Nevertheless, these findings also show that even though Grade IX had a more uniform level of initial knowledge, the game-based intervention still had a positive impact on student knowledge. After the SPINERGY educational game was introduced, significant knowledge improvement occurred at all grade levels, including Grade IX. This suggests that educational game-based methods are not only effective for students with varying baseline knowledge but also for those with more homogeneous understanding. These results are confirmed by a study conducted by Utami et al., which showed that game-based learning media can significantly improve academic achievement.(30) The study found that using educational games in learning not only increased student engagement but also supported deeper understanding of the material. Thus, tailored educational interventions that address students' needs have been proven to significantly improve learning outcomes. The use of SPINERGY as an interactive educational medium is an effective strategy to improve students' knowledge of balanced nutrition and stunting prevention, both for groups with varying prior understanding and for those with more homogeneous prior knowledge, as seen in Grade IX.

Beyond teaching methods, variation in students' baseline knowledge before the intervention is also influenced by curriculum differences. For instance, Grade IX students may have already received prior instruction on balanced nutrition and stunting prevention, giving them better initial understanding compared to lower grade students such as those in Grades VII and VIII. This correlates with a study by Lubis & Hasibuan, which found that prior knowledge has a significant effect on students' academic skills.(31) Aligned with the constructivist approach to learning, students build new knowledge through past experiences and understanding. According to a study by Suparlan, constructivism is an active learning approach in which students independently build understanding by connecting new concepts with existing cognitive structures.(32) In this context, previous learning experiences greatly influence how students absorb new information. This reinforces that educational game-based approaches like SPINERGY support constructivist learning, as students build knowledge by linking new material with previously acquired concepts.

Differences in nutritional selection ability in grades VII, VIII, and IX

The SPINERGY educational game proved to play a significant role in students' nutritional selection skills, particularly in the intervention groups of Grade VII. Grade VIII also showed improvement. Additionally, the "low" category decreased to zero across all grades, indicating improved student understanding of healthy food choices. In contrast, the control group showed smaller gains, with the "moderate" category remaining dominant, indicating that conventional approaches through regular teaching without SPINERGY were less effective than game-based learning. Statistical tests revealed significant improvements in Grades VII and VIII, but in Grade IX, although nutritional selection ability increased and pre-test differences were already significant, the post-test differences between the treatment and non-treatment groups were not statistically significant.

The varying effects of the intervention across grade levels may be related to cognitive development factors. According to Piaget's theory of cognitive development, students in Grades VII, VIII, and IX are in the formal operational stage, which enables them to understand abstract concepts, test hypotheses, and absorb material without direct experience. However, despite being in the same developmental stage, differences in cognitive readiness and learning experiences remain, influencing how students respond to interventions like SPINERGY. Grade VII and VIII students are still transitioning from the concrete operational to formal operational stage, making them more responsive to concepts presented through hands-on activities. Therefore, game-based educational approaches are more effective in enhancing nutritional selection skills, as they provide more concrete and contextual learning experiences. On the other hand, Grade IX students, being more cognitively mature, may understand concepts without direct experience, making analysis- and reflection-based approaches more appropriate for them.(33)

Besides cognitive development, learning independence also affects the effectiveness of interventions. According to Fitriani & Yusri, learning independence is closely tied to students' prior understanding and experiences.(34) Grade IX students with better initial understanding tend to be more independent in applying their knowledge when choosing food, so game-based interventions may have a lesser impact on them. In contrast, students in Grades VII and VIII still require interactive experiences, making game-based methods more effective in enhancing their understanding. Therefore, SPINERGY is more beneficial for students who still need guidance, compared to those who are already accustomed to independently choosing healthy foods.

CONCLUSION

A study on the impact of the SPINERGY educational game-based health promotion media shows that the components produced, namely the Nutrient Wheel, Nutrient Cards, Physical Challenges, Game Guide, and Handbook, are considered an attractive and effective alternative learning media. The implementation of SPINERGY demonstrated a significant increase in knowledge about stunting and balanced nutrition in the intervention group across all grades (VII, VIII, and IX) compared to the control group. In addition, SPINERGY also contributed to improving nutritional selection ability in the intervention groups of grades VII, VIII, and IX. The analysis revealed significant differences in knowledge levels between the intervention and control groups at all grades. Significant differences in nutritional selection ability were also found in the intervention groups of grades VII and VIII compared to the control group. However, in grade IX, this difference was not statistically significant, as students in this grade already had better nutritional selection ability prior to the intervention. These findings indicate that SPINERGY has the potential to serve as an educational medium to support the implementation of the National Strategy for the Acceleration of Stunting Prevention (Stranas Stunting). To expand its applicability and reach, further research can be conducted by involving a more diverse student population and exploring different research variables. The development of SPINERGY in a digital format, such as a mobile application or online game, is recommended as an effort to enhance the accessibility and appeal of this educational media through a technology-based approach.

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