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GAME-BASED HEALTH EDUCATION FOR ADOLESCENTS: DEVELOPMENT AND EVALUATION OF THE HEAL DIGITAL BOARD GAME

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ABSTRACT

In the digital era, adolescents frequently experience limited health literacy, a condition that may negatively influence their physical, psychological, and social development. This study aimed to develop and evaluate HEAL (Healthy, Energetic, Active Life), an interactive educational board game integrated with digital literacy elements, and to examine its impact on adolescents' health knowledge. The study adopted research and development (R&D) design using the 4D model, encompassing defining, designing, developing, and disseminating stages. The effectiveness of HEAL was assessed among 90 senior high school students divided into three groups using a pre-test and post-test approach. The results demonstrated a statistically significant increase in students' health knowledge after the intervention, indicating a strong positive effect of the game-based learning media. In addition to cognitive improvement, HEAL encouraged active participation, critical thinking, and awareness of responsible digital information use. The developed instrument met established criteria for validity and reliability, confirming the robustness of the findings. Overall, the study highlights the substantial educational impact of HEAL as an engaging and practical medium that enhances adolescent health awareness while simultaneously strengthening digital literacy, supporting its integration into school-based health education programs.

Keywords: adolescent health; digital literacy; educational board game; health literacy.

INTRODUCTION

Health knowledge is one of the important aspects in adolescent development (Shapu et al., 2020). This knowledge includes an understanding of stress management, balanced nutrition, reproductive health, healthy lifestyle practices, and the ability to access and manage health-related information (Asari et al., 2025; Chou et al., 2023; Kamel et al., 2025; Mansfield et al., 2020; Mugabi et al., 2023). Nevertheless, it is also important for adolescents to apply this knowledge in their daily lives through healthy habits. To promote awareness among adolescents, it is essential to provide education on health literacy (Nagy-pénzes et al., 2022). In this context, health literacy plays a crucial role. Health literacy refers to an individual's ability to access, understand, evaluate, and use health information to make informed decisions and navigate the healthcare system effectively (Schulenkorf et al., 2022).

Embedding health literacy from an early age can strengthen knowledge and active engagement in health, ultimately contributing to improved long-term health outcomes (Ko et al., 2021). Enhancing health education interventions that address knowledge, attitudes, and practices among adolescents has strong potential to reduce malnutrition and prevent both short and long-term health consequences (Shapu et al., 2020). Nevertheless, recent evidence indicates.

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that the level of health knowledge among Indonesian adolescents remains relatively low, particularly in areas such as nutrition and reproductive health. This lack of health knowledge represents a significant risk factor and reflects a gap between the expected level of adolescent health literacy and the current condition in Indonesia. Therefore, learning and adopting appropriate health knowledge and behaviors during adolescence are crucial to enabling better health decision-making (En et al., 2023).

Research by Nafisah et al. (2023) further strengthens this argument by showing that adolescents' perceptions of early marriage are significantly influenced by their level of knowledge and peer influence. The study conducted among senior high school students in South Bogor District found that peer groups were the most dominant factor shaping adolescents' perceptions of early marriage, while age, gender, family environment, cultural environment, and access to reproductive health information did not show significant associations. These findings indicate that adolescent decision-making related to reproductive health issues is not solely determined by the availability of information but is also strongly influenced by social dynamics and peer interactions.

Enhancing adolescent health knowledge has been achieved through various methods, such as lectures, modules, and leaflets. However, these conventional approaches are often perceived as less engaging and less aligned with the characteristics of the digital generation. Given the rapid development of digital technology, integrating technology-based learning strategies into health education has become increasingly relevant. There is growing interest in the use of digital games as educational tools, as they are considered interactive, accessible, and engaging learning media. Moreover, interactive learning methodologies such as simulations and role-playing games have been shown to enhance engagement and support the retention of health-related knowledge among adolescents (Mancone et al., 2024). Interactive digital platforms also provide immediate feedback and allow adolescents to practice decision-making in safe scenarios, reinforcing correct health behaviors and correcting misconceptions (Safitri & Ester, 2023). The flexibility of digital games enables learning anytime and anywhere, supporting continuous education and long-term behavioral change.

Therefore, innovation in health education media is urgently needed. The utilization of educational games is an alternative that can address this issue. Board games are enjoyable and entertaining, and they foster active participation in the learning process. The teaching and learning process becomes better and more effective, enabling active participation from students in their learning. Board game interventions for mental health have the potential to effectively address specific needs and barriers to seeking health services among adolescents in suburban areas, while systematic reviews show that board games can improve knowledge, strengthen interpersonal interactions, and motivate participants (Respati et al., 2024).

Furthermore, the promotion of adolescent reproductive health literacy can be enhanced by government programs such as National Population and Family Planning Board (BKKBN). Through communication strategies and the use of new media, these programs provide interactive and contextually relevant content that strengthens adolescents' understanding and supports informed decision-making regarding reproductive health (Pebrianti, 2020). By integrating educational games with these government initiatives, learning becomes more engaging, and adolescents are encouraged to actively reflect on their behaviors while acquiring critical knowledge in a supportive environment.

Previous studies have proven the effectiveness of board games as educational media in various fields. For example, Nadifah and Kusumohendrarto (2024) found that the development of a history-themed board game significantly increased elementary school students' engagement and understanding of the guerrilla war led by General Soedirman, suggesting that board games can serve as effective tools for enhancing learning outcomes. Such interactive media not only deliver educational content in an engaging manner but also promote active participation and collaborative problem solving among learners. These findings support the integration of board games into health and educational interventions as a means to facilitate deeper comprehension and sustained engagement across subject domains.

However, most previous studies have focused on physical board games or general digital games, with limited research examining the development and effectiveness of digital board game adaptations specifically designed to improve comprehensive adolescent health literacy, particularly within the Indonesian context. This indicates a clear research gap that necessitates the development of an innovative and contextually relevant digital board game integrating multiple aspects of adolescent health knowledge.

According to this study, the development of a digital board game as a medium for adolescent health education is urgently needed to address the limitations of conventional and physical media. In this study, the researchers designed a digital board game called 'HEAL.' The design of the board game was adapted from the game of snakes and ladders with various adjustments.

This study aimed to develop an engaging, interactive, and educational HEAL board game about adolescent health. It also measured the effectiveness of the board game in improving adolescent health knowledge and analyzed students' responses to its use as a learning medium. The study is expected to contribute significantly to the fields of education and adolescent health. For adolescents, the HEAL board game can be a fun educational medium that also broadens their knowledge about health. For educators, this digital board game can be used as an alternative educational medium that is suitable for the characteristics of today's adolescents. In addition, the results of this study can be used as a reference for researchers in creating similar educational innovations in other fields. More broadly, this innovation can support sustainable health education efforts and serve as a model for technology-based educational media development in various disciplines.

METHOD

This study was conducted at Durenan 1 State Senior High School from August 13-15, 2025, using a research and development (R&D) approach through the 4D development model. Data collection and analysis were carried out qualitatively and quantitatively to obtain comprehensive results. The Data sources used consisted of primary data obtained directly through observation, interviews, and the implementation of pre-tests and post-test.

The research was carried out in two main phases: the development phase and the effectiveness testing phase. In the development phase, initial observations and interviews were conducted to identify students' needs in improving health literacy. The findings were analyzed to determine the characteristics and functional requirements of the educational media. A literature review from journals, books, and credible online sources was also conducted to support the development process and ensure alignment with established health education concepts.

The instruments used to measure students' health knowledge were adapted from previously published journal articles related to adolescent health literacy. The adaptation process was conducted by the researchers to ensure suitability to the local context of Indonesian senior high school students. Several items were revised in terms of language clarity, terminology, and contextual relevance to match students' cognitive levels and sociocultural background. The core constructs of the original instrument were maintained to preserve its theoretical foundation.

A pilot test was conducted with 30 students from class XII-A. This class was selected using intact group sampling. XII-A was chosen because students in this class had previously participated in a health education program conducted by the school health unit (UKS), which was expected to support better comprehension during instrument testing and improve the quality of evaluation. The pilot test results were used to assess validity and reliability and to finalize the instrument.

Instrument validity was analyzed using Pearson Product Moment correlation with an r-table value of 0.361. An item was considered valid if the calculated r-value was higher than the r-table value or if the significance value ($p<0.05$) was met. Reliability was assessed using Cronbach's Alpha and the Guttman Split-Half coefficient.

The effectiveness phase employed a quasi-experimental design using a pre-test–post-test control group design. Two intact classes were involved: Class XI-A as the experimental group and

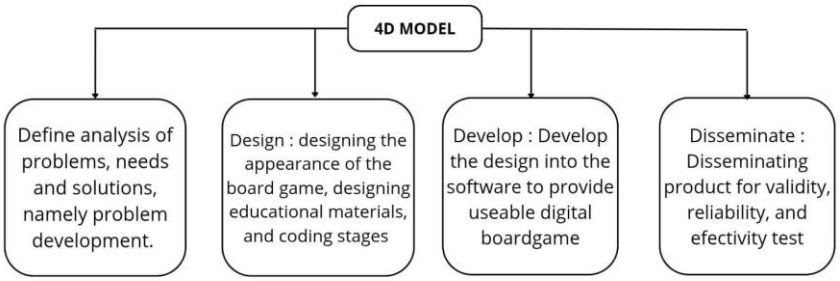
Class XI-B as the control group, each consisting of 30 students. These classes were selected because they had comparable academic performance based on school records, were taught by the same biology teacher, and had similar learning conditions. The use of intact classes was also intended to maintain natural classroom settings and minimize disruption to school activities.

Both groups completed a pre-test before the intervention. The experimental group received treatment through the implementation of the HEAL digital educational game, while the control group received conventional instruction without the game-based intervention. After the intervention, both groups completed a post-test to measure changes in health knowledge. Statistical analysis was conducted to compare pre-test and post-test scores to determine the effectiveness of the intervention.

Statistical analysis was conducted using inferential statistics. An independent sample t-test was used to compare the mean scores between the experimental and control groups. The level of significance was set at $\alpha=0.05$, where $p<0.05$ was considered statistically significant.

The R&D procedure in this study refers to Martin (2015), and the 4D development model was adapted from Wardani et al. (2019). To enhance the credibility of the findings, methodological triangulation was applied, particularly through systematic observation to ensure consistency and accuracy. The stages of the 4D model are presented in Figure 1.

Figure 1: 4D Model.



Source: Wardani et al., 2019.

The implementation of the 4D development model in this study is described as follows:

a. Define

In the Define stage, the researchers identified the problem of limited health literacy among adolescents through classroom observations, interviews, and literature review. A needs analysis was conducted to determine students' learning characteristics and preferences, including ease of use, visual attractiveness, and interactive content delivery. This stage also involved identifying the core health concepts that would be integrated into the digital game to ensure alignment with the curriculum and students' cognitive levels.

b. Design

During the design stage, the results of the needs analysis were translated into a structured plan for the educational game. This process included designing the user interface, organizing health education materials, and developing a system flowchart to illustrate user navigation and interaction. The objective of this stage was to produce a clear and systematic blueprint prior to product development.

c. Develop

In the Develop stage, the planned design was transformed into a functional digital educational game (HEAL). The product was reviewed by a biology teacher to ensure content accuracy, language clarity, and appropriate difficulty level. Feedback from the review was used to revise and refine the media. A pilot test was conducted to evaluate the validity and reliability of the instrument and to further improve the product before classroom implementation.

d. Disseminate

The dissemination stage involved implementing the finalized product in a real classroom setting to examine its effectiveness. A quasi-experimental design with a pre-test and post-test control group was employed to measure the impact of the HEAL digital game on students' health knowledge. The results of this stage were used to determine the overall effectiveness of the developed media.

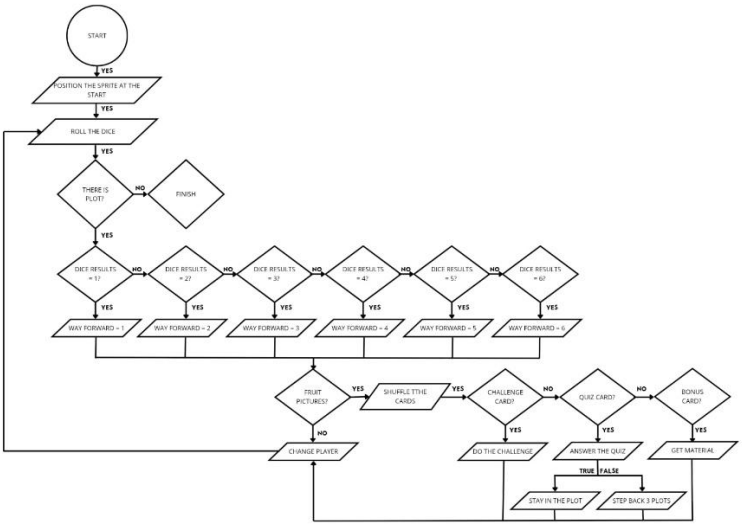
RESULTS AND DISCUSSION

The HEAL educational game is a digital-based game designed to increase adolescents' knowledge and awareness of health. The game is a modified version of snakes and ladders and can be played by two players.

This game can be played by two players. The winner is determined based on which player reaches the finish line first. Some of the squares in HEAL have a 'fruit' symbol on them. If a player lands on a square with a fruit symbol, they must shuffle the cards. There are three cards, namely (1) Challenge Card, which contains challenges that must be completed by the player, (2) Quiz Card, which contains questions that must be answered by the player by clicking on the answer they think is correct. If the answer is correct, the player stays in place. If the answer is incorrect, the player must move back three steps. (3) Bonus Card, this card contains material that must be memorized, as the material on this card may appear in the quiz.

Figure 2: Game Display and Flowchart.





Source: Data processed by the authors, 2025.

Based on interviews and observations at Durenan 1 State Senior High School, students exhibit the following patterns: (1) class 10 students often have irregular sleep schedules, low physical activity, and unbalanced nutrition, (2) class 11 students are more prone to excessive gadget use, irregular lifestyles, poor sleep, and unhealthy eating habits, and (3) class 12 students face high academic pressures, competition for achievements, and family-related challenges, which can affect sleep quality, diet, physical activity, and stress management.

To confirm that the instruments used in this game employ valid and reliable questions, validity and reliability tests were conducted.

Table 1: Validity Test Results.

Code	Grille	Question	Pearson Correlation	Sig. (2-tailed)
B1	Effects of Smoking	What are the negative effects of smoking on young people? (Setyani & Sodik, 2018).	0,407*	0,026
B2	Mental Health	Who experiences anxiety more often when there are mental health problems? (Fathirezaie et al., 2024).	0,146	0,441
B3	Ideal Sleep Time	How many hours of sleep are ideal for an adolescent? (Chen et al., 2022).	0,356	0,054
B4	Mental Health	How can toxic friendships affect teenagers' mental health? (Fadhilla & Siregar, 2024).	0,579**	0,001
B5	Healthy lifestyle	What habits are included in a healthy lifestyle? (Safarina et al., 2024).	0,574**	0,001
B6	Health reproduction	Why is it important for adolescents to maintain reproductive health? (Wardiyah et al., 2022).	0,382*	0,037
B7	Impacts of energy drinks	What are the physical impacts of excessive energy drink consumption? (Widiantari & Daryaswanti, 2023).	0,276	0,141
B8	Risks of poor sleep patterns	What are the health risks associated with irregular sleeping patterns? (Putra et al., 2017).	0,574**	0,001
B9	Gadget addiction disorder	What disorders do gadget addicts experience? (Aydın et al., 2025).	0,280	0,134

B10	Growth period	Why do adolescents need more water intake during their growth period? (Widiantari & Daryaswanti, 2023).	0,501**	0,005
B11	Sugar intake limit	What is the daily sugar intake limit to avoid tooth decay according to the WHO? (Hajishafiee et al., 2023).	0,160	0,400
B12	Obesity	What diseases can be triggered by obesity? (Tazkiah et al., 2024).	0,461*	0,010
B13	Irregular menstruation factors	What factors can cause irregular menstruation in adolescent girls? (Astuti, 2023).	0,533**	0,002
B14	Anaemia factors	What are the factors that cause anemia in adolescents? (Budiarti et al., 2020).	0,473**	0,008
B15	Sport	Give examples of sports that are beneficial for the mental and physical health of teenagers! (Esih & Pramono, 2021; Ngaru et al., 2022; Putri et al., 2020).	0,465**	0,010
**. Correlation is significant at the 0.01 level (2-tailed).				
*. Correlation is significant at the 0.05 level (2-tailed).				

Source: Data processed by the authors, 2025.

The instrument validity test results are shown in Table 1. An instrument is considered valid if the sig. (2-tailed) value is <0.05. To determine the validity of the questions, the table r and calculated r can also be used. If the calculated r-value is >r table, then the question is considered valid. The r table value based on the sample size is 0.361. Based on the validity test results, it can be seen that 10 of the 15 instrument questions are valid, while the other 5 instrument questions are invalid. The questions from the invalid instruments are B2, B3, B7, B9, B11 (mental health, ideal sleeping hours, impact of energy drinks, gadget addiction, sugar intake limits). The reliability test results show that ten questions on the instrument used have met the reliability requirements with a Guttman Split-Half Coefficient score of 0.625; Cronbach's Alpha value of 0.672 for questions B1, B4, B5, B6, B8 and 0.602 for questions B10, B12, B13, B14, B15. Furthermore, to determine the effect of using the gameboard on students' knowledge, an independent sample t-test was conducted on the experimental class and the control class.

- Table r (sample size) = 0.361
- Summary: 10 out of 15 instrument questions are valid; the invalid items are B2, B3, B7, B9, and B11.
- Instrument Reliability Results:
  - Cronbach's Alpha: 0.672 (B1, B4, B5, B6, B8), 0.602 (B10, B12–B15)
  - Guttman Split-Half Coefficient: 0.625
  - Interpretation: The instrument is generally reliable for measuring adolescent knowledge.

Table 2: T-Test Results.

Independent Samples Test								
		T	df	p-value	Mean Difference	Std. Error Difference	95% CI	
							Lower	Upper
Value	Equal variances assumed	-4,639	58	0	-13	2,803	-18,61	-7,39
	Equal variances not assumed	-4,639	58	0	-13	2,803	-18,61	-7,39

Source: Data processed by the authors, 2025.

The independent samples t-test results are shown in Table 5.2 with a confidence level of 95%. The independent samples t-test results show that there was a significant difference between the two groups (t=-4.639; df=58; p<0.001). The average knowledge of the control group was 13 points lower than that of the treatment group. The 95% confidence interval (-18.61 to -7.39) confirms that this difference is consistent and does not include zero. This indicates that knowledge about adolescent health in the experimental class is higher than in the control class. Therefore, it can be concluded that the developed game is effective in improving knowledge about adolescent health using a valid and reliable instrument. There is a significant difference (p<0.001) between experimental and control groups. The experimental group scored on average 13 points higher, showing that the HEAL game effectively improves knowledge about adolescent behaviors and lifestyle choices.

DISCUSSION

Analysis of Research Findings

The validity test of the research instrument showed that 10 out of 15 questions were valid, while five questions (B2, B3, B7, B9, and B11) were invalid. Although the invalidity was identified through statistical testing in this study, it is important to consider potential contributing factors, such as differences in students' literacy levels, comprehension of the tested concepts, and possible ambiguity in question wording. Designing instruments that match the participants' context is crucial for obtaining accurate and meaningful measurements. Reliability tests revealed Cronbach's Alpha values ranging from 0.602 to 0.672, with a Guttman Split-Half Coefficient of 0.625, demonstrating that the instrument is generally reliable for measuring adolescent knowledge. The independent samples t-test showed a 13-point average score difference between the experimental and control groups, confirming the HEAL educational game's effectiveness in improving knowledge related to adolescent behaviors and lifestyle choices.

Analysis of Patterns and Relevance of HEAL Intervention for Adolescents

A detailed analysis of behavioral patterns among adolescents shows different challenges across grades. Grade 10 students more often experience sleep disturbances and low physical activity, grade 11 students are more prone to excessive gadget use and unhealthy eating habits, while grade 12 students face academic pressures and family-related challenges that can influence sleep, diet, physical activity, and stress management. These patterns suggest that HEAL is not only effective in increasing general knowledge but also provides a contextually relevant tool for behavioral guidance and educational support tailored to adolescents' needs.

Role of Digital Media in Promoting Positive Behavioral Change

Digital media, including educational games, has significant potential to foster positive behavioral change when integrated with appropriate content. Adolescents are highly active internet users, and unregulated online gaming may negatively affect time management, sleep, social interaction, and learning productivity (Anggraeni et al., 2024; Meilinda et al., 2020; Padilah & Nashrillah, 2024). However, studies also show that adolescents tend to use social media and digital platforms to seek reproductive health information, so guided digital media use can support positive behavioral learning and effective health messaging (Dida et al., 2019; Maulana, 2021).

The digital literacy component of HEAL helps students recognize the positive and negative impacts of digital media, filter information, detect misinformation, and enhance critical thinking. Similarly, co-designed digital interventions have been shown to enhance adolescents' digital health literacy and confidence in appraising online health information (Hawkins et al., 2025). Additionally, gamified learning through challenge cards, quizzes, and bonuses encourages active participation, reflection, and repetition, reinforcing conceptual understanding. Collaborative elements, such as discussions and group problem-solving, strengthen communication, teamwork, decision-making, and self-regulation skills, supporting adolescents' behavioral development (Riduan et al., 2023).

This is also supported by previous research by Fine et al. (2025), which found that culturally adapted visual media, such as educational comics, can enhance children's awareness,

responsibility, and understanding of bodily autonomy. Furthermore, research by Budiono (2024) highlights the role of parents in shaping children's digital behavior through effective communication, mentoring, and modeling responsible technology use. Additionally, research by Ayuwardany and Kautsar (2021) emphasizes that family factors, parental education, and household environment significantly influence adolescents' decision-making, including the probability of early marriage. Moreover, systematic evidence suggests that serious games designed for adolescent health promotion can improve knowledge, attitudes, and behavioral outcomes (Andrew et al., 2023). These findings reinforce the argument that creative, contextually relevant media and supportive adult guidance are critical for delivering sensitive health content and promoting positive adolescent behavior.

Educational Implications and Challenges

The improvement in students' knowledge through HEAL confirms that digital educational games can serve as effective intervention strategies. Active engagement with interactive content allows students to reflect on their behavior patterns, manage stress, and adopt healthier habits.

The development of the HEAL digital board game in this study represents an innovative approach to adolescent health education. By integrating interactive gameplay, challenge cards, and quizzes, HEAL encourages active engagement, reflection, and repetition, supporting conceptual understanding and practical application of health knowledge. Unlike general educational games, HEAL was specifically designed to address multiple aspects of adolescent health literacy, tailored to the Indonesian context.

While previous studies have shown that digital games can improve knowledge and motivation in adolescents, HEAL provides a novel, contextually relevant intervention. The main challenges include ensuring consistent participation, managing differences in digital literacy, and maintaining focus amidst potential distractions from social media. Collaboration between schools, families, and relevant stakeholders is crucial to maximizing HEAL's impact, creating a supportive environment where adolescents can practice healthy behaviors and decision-making skills in a safe and engaging context.

Despite its effectiveness, challenges remain, including distractions from social media, variations in digital literacy, and differences in students' technology skills. Thus, the roles of teachers, parents, and collaboration among stakeholders are critical in guiding technology use, setting limits, and creating a supportive learning environment. Future development of HEAL may include integrating more specific content tailored to each grade level and adolescents' behavioral contexts and embedding parental or teacher feedback mechanisms to reinforce behavioral change. Integration of government programs through digital media, such as BKKBN's GenRe (Generation Planning) outreach program, can strengthen these strategies by providing relevant and interactive content for adolescents (Maulana, 2021).

Implementing educational games highlights the importance of collaboration among schools, families, and relevant institutions to maximize digital media's positive effects. With appropriate strategies, digital media can enhance knowledge, foster 21st-century skills such as critical thinking, creativity, collaboration, and digital literacy, and enable adolescents to utilize technology responsibly and productively (Ariyanti et al., 2025).

CONCLUSION

The findings of this study indicate that the HEAL (Healthy, Energetic, Active Life) game has significant implications for policy, practice, knowledge development, and future research in adolescent health and public health education. From a policy perspective, the effectiveness of HEAL supports its integration into school-based health programs, particularly through school health units (UKS), as a complementary strategy to strengthen adolescent health literacy. Education authorities and public health institutions, including those involved in adolescent reproductive health and family planning programs, may consider incorporating game-based learning approaches into health education curricula to improve students' awareness of healthy lifestyle choices, risk behaviors, and informed decision-making related to reproductive health.

In practical terms, HEAL provides an accessible and engaging learning tool that can be used by teachers, school counselors, and health educators in both formal and non-formal educational settings. Its interactive design encourages active participation, critical thinking, and meaningful engagement, making health education more effective and appealing to adolescents. The media is also suitable for schools with limited technological infrastructure and can be adapted for community-based youth programs to promote broader health awareness.

This study contributes to knowledge by providing empirical evidence that a hybrid digital educational game can effectively enhance adolescents' health knowledge in a school-based context. It strengthens the application of game-based learning within constructivist and cognitive learning frameworks by demonstrating how interactive and experiential learning can improve understanding of health-related concepts. This study also adds to the literature by integrating digital learning innovation with adolescent health education in an Indonesian context.

However, this study has several limitations. It focuses only on short-term cognitive outcomes without assessing long-term behavioral changes. The sample is limited to a single school, which may limit generalizability. In addition, the study does not include direct measurement of family involvement or decision-making related to adolescent reproductive health. Future research is recommended to involve larger and more diverse populations, explore long-term behavioral outcomes, and examine the role of family engagement in supporting adolescent health and family planning education.

Artificial Intelligence (AI) Use Disclosure

Artificial intelligence tools were used in the preparation of this manuscript to support language editing, improve clarity, and assist in structuring ideas. The use of AI contributed approximately 60% to language refinement and organizational support, particularly in enhancing readability and coherence of the text. However, all AI-generated suggestions and wording were critically reviewed, revised, and validated by the authors. The final content reflects the authors' full academic responsibility, with AI-generated wording limited to a maximum of 30% and substantially modified to ensure originality, accuracy, and alignment with the study's objectives.

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