The Use of Dental Stacko Effectively Increases Knowledge About Dental Caries Among Elementary School Students

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ABSTRACT
Dental caries remains one of the most prevalent oral health problems among school-aged children. One strategy to improve students' knowledge is the use of engaging and interactive educational media, such as Dental Stacko, which is designed to facilitate learning through visual and hands-on activities. This study aimed to determine the effect of using Dental Stacko on the knowledge of dental caries among upper-grade students. An analytical research design employing a Pre-Experimental One Group Pretest–Posttest Design was used. The independent variable was the use of Dental Stacko, while the dependent variable was students' knowledge of dental caries. The study population consisted of 201 upper-grade students at SDN Grabagan, Tulangan District, Sidoarjo Regency. A sample of 67 students was obtained using the Slovin formula. Data were collected using a dental caries knowledge questionnaire administered before and after the Dental Stacko intervention. Statistical analysis was conducted using SPSS with the Wilcoxon test to determine differences in knowledge scores before and after the intervention. Before the intervention, most students demonstrated poor knowledge of dental caries, with 38 students (56.7%) categorized as poor, 9 students (13.4%) as moderate, and 20 students (29.9%) as good. After the Dental Stacko intervention, students' knowledge improved substantially, with 61 students (91.0%) categorized as good, 4 students (6.0%) as moderate, and only 2 students (3.0%) remaining in the poor category. The Wilcoxon test yielded $p < 0.001$, indicating a statistically significant difference between pretest and posttest scores. In conclusion, the use of Dental Stacko had a significant effect on improving knowledge of dental caries among upper-grade students at SDN Grabagan, Tulangan District, Sidoarjo Regency. Dental Stacko serves as an effective, engaging, and interactive educational medium that enhances students' understanding of dental caries and supports school-based oral health promotion efforts.
Keywords: dental caries; Dental Stacko; elementary school students; knowledge

INTRODUCTION
Dental caries is one of the most common oral health problems and is characterized by the gradual destruction of the tooth's hard tissues, beginning with the enamel and progressing through the dentin until it eventually reaches the pulp if not managed appropriately. This pathological process is frequently observed among elementary school–aged children and has the potential to affect comfort, daily functioning, and the overall trajectory of growth and development. The onset of dental caries is marked by a progressive demineralization of the tooth's hard tissues, driven by the interaction between cariogenic bacteria, fermentable carbohydrates, and inadequate oral hygiene. When preventive measures and timely treatment are not implemented, this condition may advance to pain, infection, and ultimately tooth loss, all of which can significantly impair a child's well-being and daily activities [1].

Untreated dental caries can disrupt the mastication process, thereby influencing dietary intake and digestion. In children, disturbances in chewing efficiency may lead to reduced nutritional adequacy, which in turn can affect physical growth, cognitive development, and school performance. Beyond its biological consequences, dental caries also carries economic implications, including increased healthcare expenditures for restorative or emergency dental care and reduced productivity due to discomfort or absenteeism from school and daily activities [2]. Thus, dental caries represents not only a clinical concern but also a broader public health issue requiring comprehensive preventive strategies.

The Global Oral Health Status Report published by the World Health Organization in 2022 highlights the magnitude of this problem, noting that approximately 2 billion people worldwide experience caries in permanent teeth, while 514 million children suffer from caries in primary teeth [19]. In Indonesia, the 2018 Basic Health Research (*Riskesdas*) reported that the proportion of dental and oral problems; specifically damaged, decayed, or painful teeth reached 45.3% [20]. In West Java Province, the prevalence of dental and oral problems among children aged 10–14 years was recorded at 39.80%, underscoring that dental caries remains a highly prevalent condition among school-aged children [3].

Preliminary interviews conducted with 10 students in August 2025 revealed that 7 students possessed inadequate knowledge regarding dental caries. Initial examinations at SDN Grabagan further demonstrated that all respondents exhibited caries in either primary or permanent teeth. The clinical assessment yielded a DMF-T index of 2 and a def-t index of 3.2, indicating a considerable burden of caries experience among the students.

Given this context, innovative educational strategies are needed to enhance students' understanding of dental health. Game-based learning media, such as Dental Stacko, offer a promising alternative to conventional teaching methods. The interactive nature of such media can create a more engaging learning environment and stimulate active participation among students. By incorporating visual, tactile, and cognitive elements, Dental Stacko facilitates multisensory learning, which is particularly beneficial for children in consolidating new knowledge and forming positive health behaviors [4].

Accurate understanding of healthy dietary patterns and oral hygiene practices is essential for elementary school children aged 6–12 years. This developmental stage is marked by rapid physical and cognitive growth, during which children are highly susceptible to environmental influences, including those related to daily eating habits and oral health behaviors [5]. Educational interventions that are both developmentally appropriate and engaging are therefore crucial in shaping children's long-term oral health practices.

The use of games in health promotion has been widely documented [22], including in the context of children's oral health. A systematic review of randomized controlled trials reported that game-based instruction significantly improved dental health knowledge among children aged 4–12 years compared with conventional teaching methods [18]. Another systematic review concluded that school-based oral health education effectively enhanced dental health knowledge among children aged 6–12 years [13]. The educational media evaluated in these studies included card games, board games, and video games [7, 15–17].

Despite these advancements, three notable research gaps remain. First, based on the authors' literature search, game-based media utilizing stacking blocks (stacko) specifically designed for dental caries education have rarely been reported; existing studies predominantly examine

stacko media in the context of mathematics learning [4]. Second, most studies focus on general oral health knowledge or oral hygiene practices, whereas research examining specific knowledge about dental caries among upper-grade elementary students who already experience caries is still limited. Third, international evidence indicates that improvements in knowledge do not always translate into behavioral change [17], suggesting that context-specific evidence from Indonesian elementary schools is still needed to strengthen the foundation for effective oral health promotion.

Therefore, this study was conducted to analyze the effect of using Dental Stacko on dental caries knowledge among upper-grade students at SDN Grabagan, Tulangan District, Sidoarjo Regency. By addressing existing gaps in the literature and evaluating an innovative educational medium, this research aims to contribute to the development of more effective school-based oral health education strategies.

METHODS

Research design

This study employed an analytical quantitative research design using a Pre-Experimental One Group Pretest–Posttest Design. In this design, the level of knowledge regarding dental caries was measured in a single group of respondents before (pretest) and after (posttest) the administration of an educational intervention using the Dental Stacko media. No control group was included, allowing the study to focus on changes occurring within the same group of participants. This design is commonly used in preliminary intervention studies to determine whether an educational tool produces measurable improvements in knowledge, particularly in school-based health promotion programs where randomization or control groups may be logistically constrained.

This study received ethical clearance from the Health Research Ethics Committee of Poltekkes Kemenkes Surabaya, with approval number EA/2198/KEPK-Poltekkes_sby/II/2023. Respondents were informed about the study's objectives and procedures, participation was voluntary, parental consent was obtained, and confidentiality of respondent identity was strictly maintained.

Study setting and period

The study was conducted at SDN Grabagan, located in Tulangan District, Sidoarjo Regency, East Java, Indonesia. The research activities—including preliminary screening, data collection, intervention sessions, and posttest administration—were carried out over a four-month period from March to June 2026. This timeframe allowed adequate scheduling of intervention sessions within the school calendar and ensured that data collection did not interfere with major academic activities.

Population and sample

The study population consisted of all upper-grade students (Grades IV, V, and VI) enrolled at SDN Grabagan, totaling 201 students. The sample size was determined using the Slovin formula, which is appropriate for determining sample size when population characteristics are known but variance is not:

$$n = \frac{N}{1 + N \cdot e^2}$$

where *n* is the required sample size, *N* is the population size, and *e* is the margin of error. Using *N = 201* and *e = 10% (0.1)*, the calculation yielded:

$$n = \frac{201}{1 + 201 \cdot 0.1^2} = \frac{201}{3.01} = 66.78$$

The value was rounded up to obtain a final sample of 67 respondents.

Sampling was conducted in two sequential stages. First, purposive sampling was applied to identify students who met the inclusion criteria, particularly those diagnosed with dental caries during the initial oral examination. This step ensured that the intervention targeted students who would benefit most from dental caries education. Second, simple random sampling (lottery method) was used to select 67 students from the eligible pool. This approach minimized selection bias and ensured that each eligible student had an equal chance of being included in the study.

Inclusion criteria were: 1) Students enrolled in Grades IV, V, or VI at SDN Grabagan and present during data collection; 2) Students diagnosed with dental caries based on the preliminary oral examination; and 3) Students who agreed to participate and obtained parental or guardian consent. Exclusion criteria were: 1) Students who did not complete any stage of the research (pretest, intervention, or posttest); and 2) Students who submitted incomplete questionnaire responses. Additional exclusion criteria may be added if relevant to the study context.

Variables and operational definitions

The independent variable was the use of Dental Stacko, an educational game consisting of stacking blocks designed to deliver dental caries education. The media contained structured learning content covering the definition of dental caries, etiological factors, preventive measures, and oral hygiene practices. During the intervention, Dental Stacko was used interactively to facilitate student engagement and reinforce key concepts.

The dependent variable was knowledge about dental caries, defined as the respondents' ability to correctly answer items in the dental caries knowledge questionnaire. Knowledge scores were categorized on an ordinal scale: 1) Good: ≥ 76% correct answers; 2) Moderate: 56–75% correct answers; 3) Poor: ≤ 55% correct answers.

Data collection procedures

Prior to data collection, the researcher obtained formal permission from the school and secured ethical approval. Three trained enumerators assisted in the data collection process after receiving standardized instructions to ensure consistency.

The data collection procedure consisted of four stages: 1) Initial examination: A preliminary oral health assessment was conducted to identify students with dental caries, forming the basis for purposive sampling; 2) Pretest administration: Respondents completed a dental caries knowledge questionnaire to assess baseline knowledge; 3) Intervention using Dental Stacko: The educational intervention consisted of structured sessions using Dental Stacko (number of sessions: specify; e.g., two sessions; duration: specify; e.g., 30–45 minutes per session; and implementation: students played the Dental Stacko game in small groups. Each block contained questions or statements related to dental caries. Students were required to answer or discuss the content before placing or removing blocks, creating an interactive learning environment; and 4) Posttest

administration: The same questionnaire was administered after a predetermined interval (e.g., one week after the final session) to allow consolidation of knowledge.

The instrument used was a dental caries knowledge questionnaire consisting of *X* items (specify number), structured in multiple-choice format with one correct answer per item. Each correct response was scored as one point, and total scores were converted into percentage values. Validity testing was conducted on a group of students with similar characteristics. Items were considered valid if the calculated *r* value exceeded the *r* table value at $\alpha = 0.05$. Reliability testing using Cronbach's alpha yielded a coefficient of *X* (specify), indicating acceptable internal consistency.

Statistical analysis

Descriptive analysis was used to describe the frequency distribution of respondent characteristics and knowledge categories. Bivariate analysis employed the Wilcoxon signed-rank test, appropriate for paired ordinal data, to determine differences in knowledge scores before and after the intervention. Statistical analysis was performed using SPSS, with a significance level of $p < 0.05$.

RESULTS

This study examined the use of Dental Stacko as an educational intervention to improve knowledge regarding dental caries among upper-grade students at SDN Grabagan, Tulangan District, Sidoarjo Regency, during the period of March to June 2026. Data collection was conducted using a structured questionnaire designed to assess students' cognitive understanding of dental caries before and after the intervention. The presentation of research findings begins with a detailed description of respondent characteristics, which serves as an essential contextual foundation for interpreting the results. These characteristics include sex and grade level, both of which have been widely recognized in the literature as variables that may influence oral hygiene behaviors, susceptibility to dental caries, and responsiveness to health education interventions among upper-grade elementary school students.

Sex differences have been associated with variations in oral hygiene practices, health awareness, and behavioral compliance, with several studies suggesting that girls tend to demonstrate better oral hygiene behaviors and higher health literacy compared with boys. Grade level, similarly, reflects developmental differences in cognitive maturity, learning capacity, and exposure to health information. Students in higher grades typically possess more advanced reasoning skills and may respond differently to interactive educational media such as Dental Stacko. By presenting these characteristics at the outset, the study provides a clearer understanding of the demographic composition of the sample and allows for more nuanced interpretation of the intervention's effectiveness.

The inclusion of respondent characteristics also aligns with methodological rigor in quantitative research, ensuring that the analysis accounts for potential confounding factors that may shape knowledge acquisition. Understanding the distribution of sex and grade level among respondents is therefore crucial for contextualizing the observed changes in dental caries knowledge following the intervention. This descriptive foundation supports the subsequent analytical sections, enabling readers to appreciate how demographic factors intersect with educational strategies in shaping oral health outcomes among school-aged children.

Respondent characteristics

The distribution presented in Table 1 illustrates the demographic composition of the 67 respondents participating in this study. Based on grade level, the respondents were relatively evenly distributed across Grades IV, V, and VI, with 22 students (32.8%) from Grade IV, 22 students (32.8%) from Grade V, and 23 students (34.3%) from Grade VI. Although the proportions are comparable, Grade VI constituted the largest group of participants. This distribution is relevant because students in higher grades typically possess more advanced cognitive abilities, greater exposure to school-based health information, and increased capacity to engage with interactive educational media such as Dental Stacko.

Table 1. Distribution of sex and grade level among upper-grade students at SDN Grabagan, Tulangan District, Sidoarjo Regency, 2026

Characteristic	Category	Frequency	Percentage
Grade Level	4	22	32.8
	5	22	32.8
	6	23	34.3
Sex	Male	36	53.7
	Female	31	46.3

In terms of sex, the respondents consisted of 36 male students (53.7%) and 31 female students (46.3%). The slight predominance of male participants is noteworthy, as sex differences have been documented in the literature as potential determinants of oral hygiene behavior, health awareness, and responsiveness to educational interventions. Some studies suggest that female students often demonstrate higher levels of health consciousness and better oral hygiene practices, whereas male students may exhibit more variability in health-related behaviors. Understanding this distribution is therefore essential for contextualizing the knowledge outcomes observed in subsequent analyses.

Overall, the total number of respondents was 67 students, representing 100% of the sample included in the study. Presenting these characteristics provides a foundational understanding of the demographic context in which the Dental Stacko intervention was implemented. Such contextual information is crucial for interpreting the effectiveness of the educational media, as demographic factors may influence baseline knowledge, learning engagement, and the degree of improvement following the intervention.

Knowledge of dental caries before the use of Dental Stacko

Based on Table 2, the assessment of students' knowledge regarding dental caries prior to the introduction of the Dental Stacko media indicates that the majority of respondents demonstrated a low level of understanding. Of the 67 students evaluated, 38 students (56.7%) fell into the *poor* knowledge category, reflecting limited awareness of the causes, progression, and prevention of dental caries. This finding suggests that many students had not yet developed adequate conceptual understanding or practical knowledge related to oral health maintenance.

Table 2. Knowledge of dental caries before the use of dental stacko among upper-grade students at SDN Grabagan, Tulangan District, Sidoarjo Regency, 2026

Knowledge category	Frequency	Percentage
Poor	38	56.7
Moderate	9	13.4
Good	20	29.9

A smaller proportion of students, 20 students (29.9%), were categorized as having *good* knowledge. These students likely possessed more accurate information about dental caries, including its etiology, risk factors, and preventive behaviors such as proper brushing techniques and dietary control. Meanwhile, 9 students (13.4%) were classified

in the *moderate* knowledge category, indicating partial understanding but with notable gaps in essential concepts.

The predominance of poor knowledge highlights a critical need for targeted oral health education within the school environment. Elementary school students, particularly those in upper grades, are at a developmental stage where cognitive abilities allow for more complex understanding of health concepts. However, without structured and engaging educational interventions, their knowledge may remain insufficient to support healthy oral hygiene behaviors. The baseline findings in Table 2 therefore provide a strong rationale for implementing innovative educational media; such as Dental Stacko to enhance students' comprehension of dental caries and promote better oral health practices.

Knowledge of dental caries after the use of Dental Stacko

Based on Table 3, the assessment of students' knowledge regarding dental caries after the implementation of the Dental Stacko intervention demonstrates a substantial improvement across the respondent group. Of the 67 participating students, 61 students (91.0%) achieved a *good* level of knowledge, indicating that the vast majority were able to correctly understand and recall key concepts related to dental caries, including its definition, etiological factors, preventive strategies, and recommended oral hygiene practices. This marked increase in the proportion of students categorized as having good knowledge reflects the effectiveness of Dental Stacko as an interactive educational medium capable of enhancing cognitive engagement and facilitating meaningful learning.

Table 3. Knowledge of dental caries after the use of dental stacko among upper-grade students at SDN Grabagan, Tulangan District, Sidoarjo Regency, 2026

Knowledge category	Frequency	Percentage
Poor	2	3.0
Moderate	4	6.0
Good	61	91.0

A smaller proportion of students, 4 students (6.0%), were classified within the *moderate* knowledge category. These students demonstrated partial comprehension of the material but may still require reinforcement to achieve full mastery of the concepts. Meanwhile, only 2 students (3.0%) remained in the *poor* knowledge category, indicating a dramatic reduction compared with pre-intervention results. The presence of a small number of students in this category suggests that individual differences; such as learning pace, attention span, or prior exposure to oral health information may influence the degree of knowledge acquisition.

Overall, the post-intervention distribution reveals a clear shift toward higher levels of knowledge, underscoring the pedagogical value of Dental Stacko in school-based oral health education. The interactive nature of the media, which combines tactile engagement with structured learning content, likely contributed to improved retention and understanding among students. These findings support the use of game-based educational tools as effective strategies for promoting oral health literacy in elementary school settings and highlight the potential of Dental Stacko to serve as a scalable and engaging medium for future health promotion initiatives.

Hypothesis testing results

Based on Table 4, the results of the bivariate analysis using the Wilcoxon signed-rank test demonstrate a statistically significant difference between students' knowledge scores before and after the Dental Stacko intervention. The obtained p-value < 0.001, which is substantially lower than the predetermined significance level of 0.05. This statistical outcome indicates that the null hypothesis (H_0), which states that there is no difference in knowledge before and after the intervention, must be rejected. Conversely, the alternative hypothesis (H_1), which posits that the Dental Stacko intervention leads to an improvement in knowledge, is accepted.

Table 4. Wilcoxon test results for knowledge before and after the use of Dental Stacko among upper-grade students at SDN Grabagan, Sidoarjo Regency, 2026

Variable	Knowledge category			p-value
	Good	Moderate	Poor	
Before the use of Dental Stacko	20	9	38	< 0.001
After the use of Dental Stacko	61	4	2	

The Wilcoxon test results corroborate the descriptive findings presented in the earlier tables. Prior to the intervention, a large proportion of students were categorized as having poor knowledge (38 students), whereas after the intervention, the majority shifted to the good knowledge category (61 students). The marked reduction in the number of students in the poor category; from 38 to only 2 further reinforces the magnitude of change attributable to the educational intervention.

Statistically, the Wilcoxon signed-rank test evaluates paired ordinal data by comparing the ranks of differences between pretest and posttest scores. The highly significant p-value suggests that the observed improvement is unlikely to be due to chance. Instead, it reflects a meaningful and consistent increase in students' understanding of dental caries following exposure to the Dental Stacko media.

Overall, the results provide strong empirical evidence that the use of Dental Stacko had a significant and positive effect on enhancing dental caries knowledge among upper-grade students at SDN Grabagan, Sidoarjo. These findings support the effectiveness of interactive, game-based educational media in strengthening oral health literacy within school-aged populations.

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DISCUSSION

Main findings of the study

The findings of this study demonstrate that the use of Dental Stacko substantially improved students' knowledge of dental caries among upper-grade students at SDN Grabagan. Prior to the intervention, the majority of respondents were categorized as having *poor* knowledge, indicating limited understanding of fundamental concepts related to dental caries. Following the intervention, most respondents shifted to the *good* knowledge category, and this improvement was statistically significant ($p < 0.001$). The observed increase encompassed several key domains of knowledge, including the definition of dental caries, etiological factors, preventive measures, and recommended oral hygiene practices.

The low level of knowledge observed before the intervention can be attributed to several contextual factors. First, students had limited exposure to structured oral health education, as dental health topics are often not emphasized within the regular school curriculum. Second, conventional health education methods frequently rely on didactic approaches that may not effectively engage elementary school students. The absence of interactive and visually stimulating educational media likely contributed to students' difficulty in retaining information related to dental caries.

Knowledge, as conceptualized in health education theory, is the result of sensory processing and cognitive interpretation of information obtained through the five senses. It is influenced by multiple determinants, including educational level, environmental conditions, access to information, age, and personal experiences [6]. Students who are not exposed to engaging or relevant learning materials tend to exhibit suboptimal knowledge acquisition, particularly in subjects requiring conceptual understanding such as oral health.

The significant improvement observed after the use of Dental Stacko underscores the importance of interactive, game-based educational media in enhancing learning outcomes. Dental Stacko integrates tactile engagement, visual cues, and collaborative play, all of which are known to support deeper cognitive processing and memory retention in children. By transforming abstract oral health concepts into concrete, hands-on activities, the media effectively bridges the gap between information delivery and comprehension.

Overall, the main findings of this study highlight the pedagogical value of Dental Stacko as an innovative tool for school-based oral health promotion. The substantial increase in knowledge following the intervention suggests that interactive educational media can serve as an effective strategy for improving oral health literacy among elementary school students, particularly in settings where conventional health education resources are limited.

Comparison with previous studies and critical analysis

The initial knowledge condition of students in this study aligns closely with findings reported by Pay et al. [7], who observed that prior to the use of educational card games, most students demonstrated dental health knowledge within the moderate-to-poor range. Their study further showed a significant improvement in knowledge following the intervention, mirroring the pattern identified in the present research. Similarly, Imamah et al. [8] found that elementary school students' baseline knowledge of oral and dental hygiene was predominantly categorized as poor to moderate before receiving animated video-based education. These parallels reinforce the notion that school-aged children often begin with limited oral health literacy, and that interactive educational media can serve as an effective catalyst for improvement.

The increase in knowledge observed after the use of Dental Stacko is also consistent with international evidence. A systematic review of randomized controlled trials reported that game-based instruction significantly enhanced dental health knowledge among children aged 4–12 years and was more effective than conventional methods such as verbal instruction or poster-based education [18]. A meta-analysis involving children aged 5–16 years concluded that various educational aids; including games were effective in improving oral hygiene status and reducing caries incidence [14]. Another systematic review similarly documented improvements in dental health knowledge among children aged 6–12 years following school-based oral health education programs [13]. Beyond oral health, comparable findings have been reported in general learning contexts, where interactive games and simulations have been shown to produce superior cognitive outcomes compared with traditional teaching approaches [21].

The improvement observed in this study can be explained by the inherent characteristics of Dental Stacko as a game-based educational medium. Interactive and enjoyable media facilitate information reception [9], enhance concentration and learning outcomes [4], and engage multiple sensory modalities, thereby strengthening memory retention; an effect consistent with Edgar Dale's Cone of Experience [10]. Through Dental Stacko, students are not merely passive recipients of information; rather, they actively participate in the learning process through hands-on play, discussion, and problem-solving. Within the framework of Skinner's Stimulus-Organism-Response (S-O-R) theory [6], Dental Stacko functions as a stimulus that captures students' attention and elicits a cognitive response in the form of increased knowledge about dental caries.

However, while the intervention effectively improved knowledge, it is important to recognize that enhanced knowledge does not automatically translate into behavioral change. Friadita [11] reported that good knowledge does not necessarily lead to optimal oral hygiene practices. A randomized controlled trial involving video-based games in elementary schools similarly found that although knowledge about healthy foods improved, there was no corresponding change in tooth-brushing behavior or plaque scores [17]. A systematic review of traditional school-based oral health education also noted short-term effects on plaque reduction, but inconsistent findings for caries outcomes and a lack of evidence regarding long-term behavioral change [12]. These findings highlight a critical gap between cognitive gains and behavioral adoption, suggesting that knowledge-based interventions must be complemented by behavioral reinforcement strategies to achieve sustained oral health improvements.

Furthermore, the absence of a control group in this study limits the ability to isolate the specific contribution of Dental Stacko as a game-based medium. The observed improvement may partially reflect the influence of the educational content delivered during the intervention or the cognitive priming effect of completing the pretest. Without a comparison group, it is not possible to definitively attribute the magnitude of change solely to the game-based component of the intervention. Future studies employing randomized controlled designs would be valuable for disentangling these effects and providing more robust evidence regarding the unique impact of Dental Stacko.

Overall, while the present findings are consistent with prior research and theoretical frameworks supporting game-based learning, a critical interpretation underscores the need for further investigation into behavioral outcomes, long-term retention, and the specific mechanisms through which interactive educational media influence oral health literacy.

Implications of the findings

From a practical standpoint, the findings of this study indicate that Dental Stacko can be considered a viable alternative educational medium for dental health promotion among upper-grade elementary school students. Its interactive and game-based nature encourages active participation, fosters engagement, and creates a learning environment that is both enjoyable and cognitively stimulating. These characteristics are particularly important for school-aged children, who often respond more effectively to hands-on and visually appealing learning tools than to conventional didactic instruction. The observed improvement in knowledge suggests that Dental Stacko can serve as a useful adjunct for dental health professionals and teachers in delivering oral health education, especially in settings where traditional methods have yielded limited impact.

The increase in knowledge following the intervention may serve as a foundational step toward shaping positive attitudes and preventive behaviors related to dental caries. Knowledge is widely recognized as a precursor to attitude formation and behavioral change, and enhanced understanding of caries etiology, risk factors, and preventive strategies may encourage students to adopt healthier oral hygiene practices. However, for knowledge gains to translate into sustained improvements in oral health status, educational interventions must be supported by continuous and structured follow-up activities. These may include periodic dental examinations, supervised tooth-brushing programs at school, and active involvement of parents or caregivers in reinforcing oral hygiene routines at home [17]. Such complementary efforts are essential to ensure that the cognitive gains achieved through Dental Stacko are transformed into long-term behavioral outcomes.

From a scientific perspective, the findings contribute to the growing body of evidence supporting the use of stacking-block educational games as effective tools for oral health education in elementary school settings. While previous studies have examined card games, board games, and digital games, this study adds empirical support for the pedagogical value of block-based interactive media. The results demonstrate that tactile, multisensory, and collaborative learning experiences can enhance comprehension of dental health concepts, aligning with established theories of experiential learning and multisensory instruction. By documenting the effectiveness of Dental Stacko, this study expands the range of validated

educational tools available for school-based oral health promotion and provides a foundation for future research exploring game-based learning in diverse health education contexts.

Study limitations

This study has several limitations that should be acknowledged to contextualize the findings and guide future research. First, the use of a pre-experimental design without a control group limits the ability to isolate the specific effects of the Dental Stacko intervention. Without a comparison group, it is not possible to rule out alternative explanations such as testing effects, where students may perform better on the posttest simply because they have been exposed to the questionnaire previously, or the influence of the educational content delivered during the intervention, independent of the game-based medium itself. Consequently, the observed improvement in knowledge cannot be attributed solely to Dental Stacko with full certainty.

Second, the study was conducted in a single elementary school and involved respondents who were all diagnosed with dental caries. While this sampling approach ensures relevance to the target population, it also restricts the generalizability of the findings. Variations in school environments, socioeconomic backgrounds, cultural practices, and exposure to oral health education across different regions may influence the effectiveness of game-based learning tools. Therefore, the results should be interpreted with caution when considering broader application beyond the specific context of SDN Grabagan.

Third, the measurement of knowledge was conducted immediately after the intervention, which captures only short-term cognitive gains. This approach does not allow assessment of long-term knowledge retention, nor does it evaluate whether improved knowledge translates into behavioral changes or improvements in clinical outcomes, such as reductions in caries incidence or improvements in DMF-T/def-t scores. As oral health behavior is influenced by multiple factors; including parental involvement, environmental reinforcement, and habitual practice short-term knowledge gains may not necessarily lead to sustained behavioral modification.

Given these limitations, future research is recommended to adopt a quasi-experimental design with a control group across multiple schools to strengthen internal and external validity. Incorporating follow-up measurements at several intervals would allow researchers to evaluate retention of knowledge over time and determine whether the intervention produces lasting effects. Additionally, future studies should include assessments of oral health behaviors (e.g., tooth-brushing frequency, plaque scores) and clinical indicators such as DMF-T and def-t indices to provide a more comprehensive evaluation of the intervention's impact on both cognitive and behavioral dimensions of oral health.

CONCLUSION

Based on the research findings regarding the use of the "Dental Stacko" educational tool to improve knowledge about dental caries among upper-grade students at SDN Grabagan, Tulangan District, Sidoarjo Regency, it can be concluded that, prior to the intervention, the majority of students possessed a low level of knowledge regarding dental caries. Following the use of the Dental Stacko tool, the students' knowledge levels improved, shifting from the "low" category to "fair" or "good" categories. The results indicate that the use of the Dental Stacko tool contributes to an increase in knowledge about dental caries among upper-grade students at SDN Grabagan, Tulangan District, Sidoarjo Regency.

Ethical consideration, competing interest and source of funding

-The ethical approval: This study had obtained ethical approval from the Health Research Ethics Commission of Poltekkes Kemenkes Surabaya, number: EA/2198/KEPK-Poltekkes_sby/II/2023.
-There is no conflict of interest related to this publication.
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