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Comparative Evaluation of Game-Based, Demonstrational, and Interactive Educational Approaches for Oral Health Promotion Among School-Age Children

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Abstract

Oral health education is a fundamental component of preventive dentistry, but children's engagement across different educational approaches remains an important area of investigation. This study aimed to comparatively evaluate observed behavioural engagement associated with interactive, demonstrational, and game-based educational approaches among school-age children. A pilot, school-based comparative observational study was conducted among 60 second-grade students at a primary school in Sofia, Bulgaria. A standardized 40 min educational session included three approaches: interactive PowerPoint presentations, demonstrations with dental models and visual tools, and game-based activities emphasizing toothbrushing skills and dietary habits. Children's engagement was assessed using three indicators: active participation and willingness to engage, confidence, and interaction with the educational materials. The game-based approach demonstrated the highest proportion of children classified in the "Very High" engagement category across all indicators. The average proportion of "very high" performance was 63.4% for the game-based approach, compared with 27.8% for the demonstrational approach and 22.8% for the interactive approach. Children participating in game-based activities demonstrated higher observed levels of participation, confidence, and interaction with educational materials. Game-based educational activities were associated with higher observed engagement during oral health education. These findings highlight the potential value of game-based activities for engaging children in oral health education. Further research using randomized designs, validated assessment instruments, and independent observers is needed to determine whether these differences in observed engagement are reproducible.

Keywords: oral health education; game-based learning; health promotion; active learning; child engagement

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1. Introduction

Dental education generally focuses on influencing individuals' behavior, which is considered a key factor in poor oral hygiene [1]. When dental professionals provide comprehensive knowledge about oral health, it can lead to improved oral hygiene practices and behavior change [2]. Nevertheless, traditional educational programs often struggle to achieve optimal oral hygiene levels because their effectiveness is influenced by additional factors like diet, dental visit frequency, educational background, economic status, political climate, and social support [3,4].

Effective dental health education programs not only promote behavioral change but also enhance the health of individuals, groups, and communities by encouraging the adoption and maintenance of healthy habits [5]. Schools are ideal settings for these programs because they include large, accessible groups of children already in an educational environment, facilitating the efficient delivery of such initiatives [6,7].

Systematic reviews emphasize the importance of education grounded in theoretical models, particularly Bandura's self-efficacy theory, in enhancing students' oral health [8,9]. This theory centers on an individual's confidence in their ability to carry out behaviors needed to achieve desired results. Bandura highlights four key factors shaping self-efficacy: personal mastery experiences, observational learning, verbal encouragement, and physical/emotional states [10,11]. For instance, high self-efficacy related to oral health correlates with better habits like regular brushing and flossing, which help reduce dental plaque and improve periodontal health [12]. The model is used to compensate for gaps in students' knowledge, skills, and behaviors by promoting repeated practice, peer learning, and emotional support, thereby boosting confidence and self-care capacity [13].

Traditional oral health education, primarily delivered through school programs including primary schools, continues to be an essential part of oral health promotion efforts. However, its long-term impact is relatively limited [14,15]. While it can enhance oral health literacy and boost knowledge temporarily, this approach alone is not sufficiently effective in fostering lasting practical skills development. Therefore, it is important to adopt more interactive and child-centered educational methods [16].

Modern pedagogical and health-education methods emphasize that children learn better through active involvement, hands-on tasks, and experiential learning. Incorporating demonstrations, exercises, role-play, and practical activities engages cognitive processes and helps retain knowledge longer. Active participation allows children to make connections between theoretical knowledge and practical experiences, making information memorable. This education method encourages children to question, analyze, and reflect as it develops natural critical thinking abilities, especially in early childhood [16].

Interactive educational approaches involve the use of digital presentations, visual materials, questioning techniques, and active communication between educators and children to facilitate learning. Demonstrational approaches rely on direct visualization and practical demonstrations, such as the use of dental models and oral hygiene tools, allowing children to observe and practice appropriate techniques. Game-based approaches incorporate playful activities and experiential learning to increase motivation and participation. Transforming educational content into playful activities may increase attention and emotional involvement.

In light of these considerations, the current study aimed to evaluate the application of interactive, game-based, and demonstrational methods in oral health education and the observed engagement of school-age children during these activities.

Aim of the programme:

This study aimed to comparatively evaluate the observed engagement of children during interactive, demonstrational, and game-based educational activities.

2. Materials and Methods

2.1. Study Design, Participants and Ethics

A total of 60 children participated in the programme. The session lasted 40 min, within one school period. The children were from two parallel 2nd-grade classes at the 34th "Stoyu Shishkov" Primary School in Sofia, Krasno Selo district.

Materials used: plastic models of teeth and jaws for visualising the structure and parts of the teeth; stationery materials for conducting experiments; food materials for demonstrating the demineralising effect of certain food products.

Study design:

This exploratory pilot study was designed as a school-based comparative observational study. Children's behavioural engagement was observed and compared during three oral health education approaches (interactive, demonstrational, and game-based) delivered within a single standardized educational session. The primary outcome measures were children's active participation, confidence, and interaction with the educational materials. The study was conducted at a primary school in Sofia, Bulgaria, during March 2026.

Study Sample:

The study included 60 second-grade students from a primary school in Sofia, Bulgaria. The study included all eligible second-grade students attending the selected school during the study period. The inclusion criteria were enrollment in the second grade, attendance at the selected school, and provision of written informed consent from parents or legal guardians. Children whose parents or legal guardians did not provide written informed consent, or who were absent during the educational session, were excluded.

The participants were aged between 8 and 9 years (mean age: 8.33 $\pm$ 0.47 years), including 39 boys and 21 girls. The sample size was determined based on the number of eligible students available at the selected school during the study period.

A structured observational assessment framework was developed specifically for this study to capture three predefined aspects of children's behavioural engagement: active participation and willingness, confidence, and interaction with the educational materials. For each indicator, three observable levels of engagement were defined (moderate, high, and very high), with behavioural descriptors provided for each level. The framework was developed according to the objectives of the educational programme and was used consistently across the three educational activities. As this was a study-specific observational framework, it was not formally validated as a psychometric instrument, and its psychometric properties were not established.

Study procedure:

The educational session lasted approximately 40 min and was conducted in a standardized manner for all participants. The session consisted of three consecutive educational modules lasting approximately 10 min each. The remaining 10 min of the overall session were used for questions, discussion, feedback, and distribution of educational gifts. The first module employed an interactive presentation introducing the basic principles of oral health and proper tooth brushing. The second module used a demonstrational approach, during which the educator demonstrated the recommended oral hygiene techniques using dental models and visual materials. The third module consisted of a game-based educational activity designed to reinforce the knowledge acquired during the previous modules through active participation and engagement.

All participants completed the three educational modules in the same sequence during a single session to ensure a standardized educational experience.

2.2. Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Medical University of Sofia (Protocol No. KENIMUS BK-684/31.03.2025, approved on 8 May 2025). Written informed consent was obtained from the parents or legal guardians of all participating children prior to inclusion in the study. Participation was voluntary, and no identifying personal data were collected. All data were processed in compliance with ethical standards for research involving minors.

2.3. Educational Methods

- *Interactive method*: information for the health education of the students was presented via a PowerPoint presentation, divided into 2 modules. The information was aligned with the curriculum and selected in accordance with the children's age characteristics.
- *Demonstrational method*: through demonstrations on a model, the students were actively engaged with the topic studied, with each presented module accompanied by a visual and accessible explanation of its content and significance.
- *Game-based method*: the game-based method included an educational game called "Little Dentists", through which children were encouraged to demonstrate the tooth-brushing techniques they had learned. The children were divided into teams, and each participant was given the opportunity to "brush" the teeth of a dental model. To increase motivation and engagement, a competitive element was incorporated: the team with the greatest number of children correctly demonstrating the brushing technique received small prizes, such as travel-sized tubes of toothpaste.

The game-based method also included an activity focused on identifying the sugar content of common foods and beverages ("Food Specialist"). Children were presented with various food products and were asked to estimate the amount of sugar contained in each item. They then matched the products with the corresponding number of sugar cubes, allowing them to visually compare sugar content across different foods.

First Module—"The Microbes and the Super-Teeth"

The first module of the program was concerned with familiarizing the children with the structure of the oral cavity and the teeth through an interactive method using a PowerPoint presentation (Figure 1):

A. Number of teeth, dentitions, groups of teeth, structure, explanation of the number of teeth;
B. Dental plaque and caries-formation, composition, relationship with caries;
C. Oral hygiene-basic rules, methods, and means;

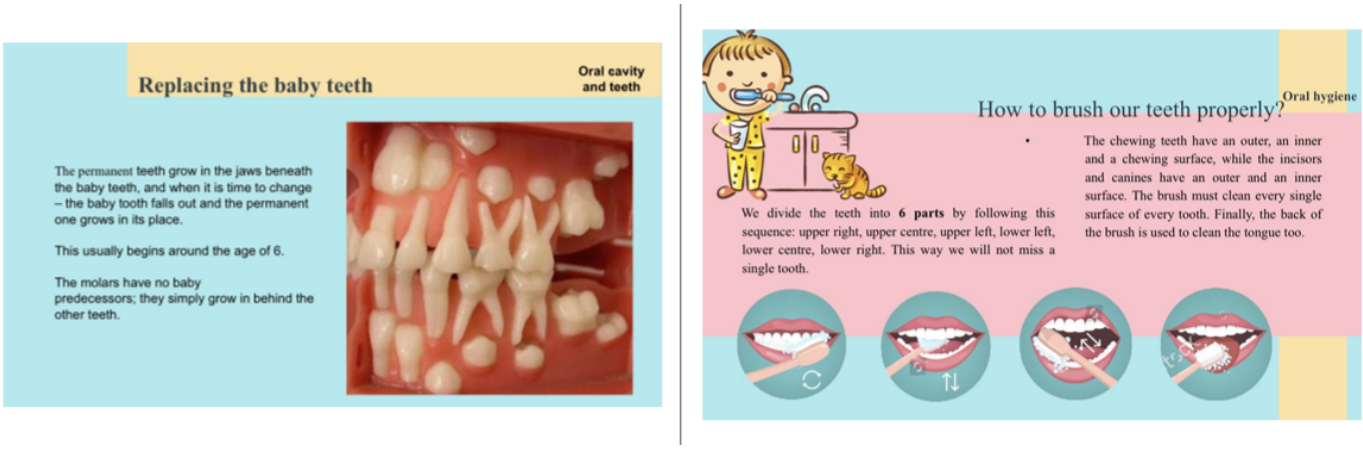


Figure 1. Interactive teaching method.

With the help of the demonstrative method, the different groups of teeth in the two jaws were presented to the children in detail using a plastic model and a booklet (Figure 2).

Second Module—"Sugar as a Hidden Enemy"

With the help of the interactive method—PowerPoint presentation, part 2—the food plate was presented to the children, and all the foods in it were discussed, as well as their distribution throughout the day's meals. PowerPoint presentation included:

- Nutrition—cariogenic and caries-protective foods, the relationship between nutrition and caries;

– Dietary habits—basic guidelines for proper nutrition.



Figure 2. Plastic model visualizing the groups of teeth.

With the help of the game-based method "Little Dentists", children were encouraged to demonstrate the tooth-brushing techniques they had learned (Figure 3).



Figure 3. Game-based methodology—mastering different brushing methods.

A demonstrative method was used to visualize the amount of sugar in the most frequently consumed drinks from the school canteen. For this purpose, a board was made which remained in the classroom to remind the children daily of the harms and to provide a visual demonstration of the enormous amount of sugar in them (Figure 4).

With the help of the game-based method "Food Specialist," the children were encouraged to estimate the approximate amount of sugar contained in certain selected foods.

To compare children's behavioural engagement for the three educational approaches, an observational assessment framework was developed. The evaluation was based on three indicators: (1) active participation and willingness to engage, (2) confidence, and (3) interaction with the educational materials.

Active participation and willingness to engage were assessed through observable behaviours such as attentive listening, maintaining focus on the activity without distraction, responding to questions, and voluntarily participating in discussions and tasks.

Confidence was evaluated through behaviours demonstrating familiarity and self-assurance, including volunteering answers, expressing prior knowledge of the topic, responding without hesitation, and actively contributing to the discussion.



Figure 4. Board showing the sugar content in different drinks.

Interaction with the educational materials was assessed by observing the extent to which children handled, examined, and explored the materials, as well as their willingness to ask questions and engage with the learning resources.

For each indicator, the level of engagement was classified as moderate, high, or very high based on the frequency and consistency of the observed behaviours during the educational activities (Table 1). No category for low or absent engagement was included in the original observational framework.

Table 1. Observational assessment framework.

Indicator	Moderate	High	Very High
Active participation and willingness	Occasional attention and participation	Frequent participation and sustained attention	Consistent participation and enthusiasm throughout the activity
Confidence	Responds when asked	Volunteers answers occasionally	Frequently volunteers answers and demonstrates strong self-confidence
Interaction with materials	Limited/Basic interaction	Regular exploration of materials	Extensive interaction, questioning, and exploration

Children's engagement during the educational activities was evaluated using a structured observational checklist based on predefined behavioural indicators. Two trained observers participated in the study. The first observer delivered the educational activities according to a standardized protocol, ensuring consistency in the implementation of the three educational methods. The second observer was responsible for the behavioural assessment of children using the predefined observational checklist. Since the educational activities were conducted by one observer and the assessments were performed by the second observer only, no independent duplicate ratings were available for inter-rater reliability analysis. The standardized observation card focused on three domains: active participation and willingness to engage, confidence, and interaction with the educational materials.

Active participation and willingness to engage were assessed through observable behaviours such as attentive listening, maintaining focus on the activity without distraction, responding to questions, and voluntarily participating in discussions and tasks. Confidence was evaluated through behaviours demonstrating familiarity and self-assurance, including volunteering answers, expressing prior knowledge of the topic, responding without

hesitation, and actively contributing to the discussion. Interaction with the educational materials was assessed by observing the extent to which children handled, examined, and explored the materials, as well as their willingness to ask questions and engage with the learning resources.

For each indicator, the level of engagement was classified as moderate, high, or very high based on the frequency and consistency of the observed behaviours during the educational activities (Table 1). The observational checklist was designed to provide a standardized assessment of children's behavioural engagement across the three educational methods. As the checklist was developed for the purposes of this study, it was not intended to serve as a validated psychometric instrument.

The observational assessment framework was designed to categorize the degree of positive engagement demonstrated by children during the educational activities. Since the purpose of the assessment was to evaluate variations in active participation, confidence, and interaction with educational materials among engaged participants, the categories included moderate, high, and very high levels of engagement. A low engagement category was not included because the assessment focused on differentiating levels of participation rather than measuring disengagement or absence of involvement.

For each participant, the observer classified performance for every indicator into one of three predefined ordinal categories: Moderate, High, or Very High, according to the criteria presented in Table 1. These categorical observations were recorded for all participants, and the frequency and percentage of children within each category were calculated for each educational method. The resulting ordinal categorical data were subsequently used for statistical comparisons between the observed engagement levels across the three educational methods.

2.4. Statistical Methods

To compare children's observed engagement levels across the three educational methods, statistical analyses were performed to examine differences in the three behavioural indicators: active participation and willingness to engage, confidence, and interaction with the educational materials. Because the same participants were assessed during all three educational methods, the comparisons were performed using a repeated-measures approach.

For each engagement indicator, the Friedman test was used to compare the ordinal engagement scores across the interactive, demonstrational, and game-based methods. The engagement categories were coded as moderate = 1, high = 2, and very high = 3, with higher scores indicating higher observed engagement.

When the Friedman test indicated a statistically significant difference, post hoc pairwise comparisons were performed using the Wilcoxon signed-rank test. Bonferroni adjustment was applied to account for the three pairwise comparisons, resulting in an adjusted significance level of $\alpha = 0.0167$. Statistical significance for the overall Friedman tests was set at $p < 0.05$.

The analyses were intended to identify differences in observed engagement across the three educational methods and were not interpreted as evidence of causal effects of any particular educational approach.

3. Results

The results of the comparative evaluation of the game-based, demonstrational, and interactive educational methods are presented below.

Children's behavioural engagement was assessed using three indicators: active participation and willingness to engage, confidence, and interaction with the educational materials. The findings are summarized in the following figures.

Figure 5 presents the levels of engagement observed during the interactive educational method. For active participation and willingness to engage, half of the children demonstrated a high level of participation, while the remaining children were classified as moderate (26.7%) or very high (23.3%). Similar results were observed for confidence.

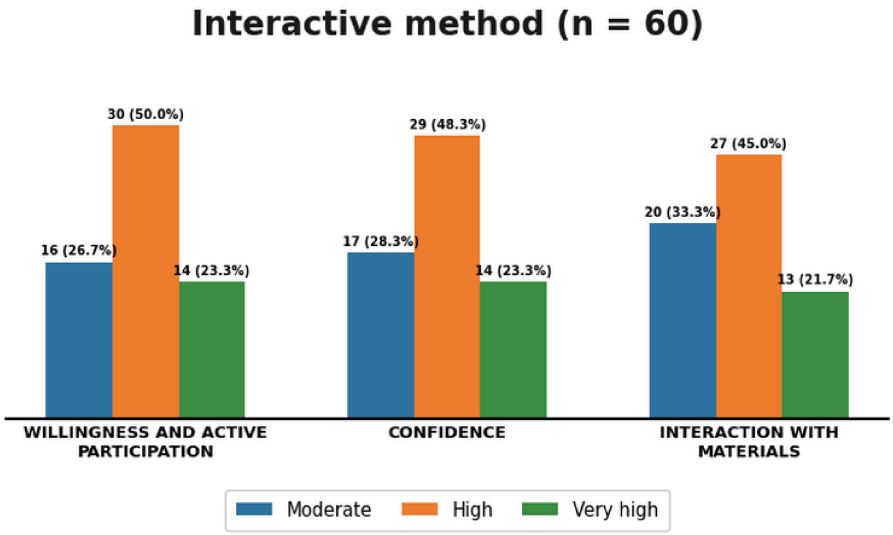


Figure 5. Distribution of assessed indicators for the interactive method (n = 60). Values are presented as n (%). Percentages are rounded to one decimal place and may therefore not sum to exactly 100%.

Regarding interaction with the educational materials, 45.0% of the children showed a high level of interaction, 33.3% a moderate level, and 21.7% a very high level. Overall, the interactive method was most frequently associated with high levels of participation, confidence, and interaction with materials.

Figure 6 presents the levels of engagement observed during the demonstrational method. Regarding active participation and willingness to engage, 50.0% of the children demonstrated a high level, 30.0% a very high level, and 20.0% a moderate level. A similar pattern was observed for confidence.

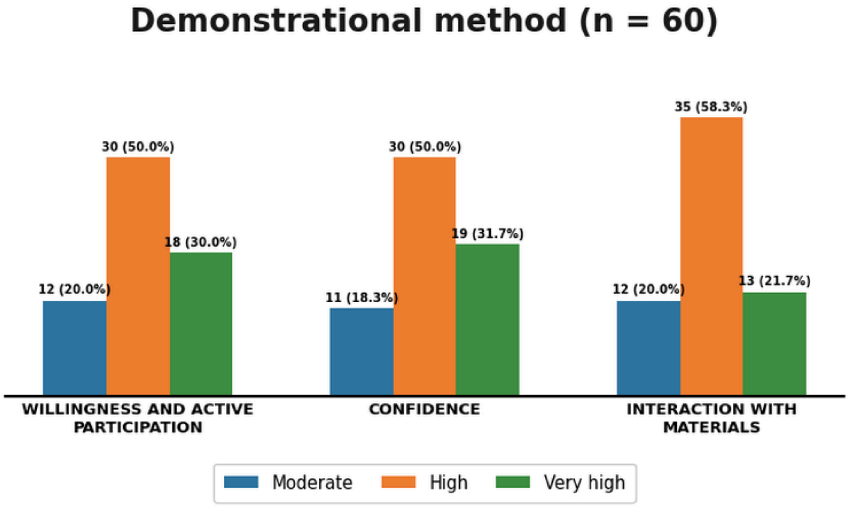


Figure 6. Distribution of assessed indicators for the demonstrational method (n = 60). Values are presented as n (%). Percentages are rounded to one decimal place and may therefore not sum to exactly 100%.

Regarding interaction with the educational materials, 58.3% of the children demonstrated a high level of interaction, while 21.7% and 20.0% were assessed as having very high

and moderate levels, respectively. Overall, the demonstrational method was predominantly associated with high levels of participation, confidence, and interaction with materials, with a relatively greater proportion of children classified in the 'Very High' category for participation and confidence than in the 'Moderate' category.

Figure 7 presents the levels of engagement observed during the game-based method. Regarding active participation and willingness to engage, the majority of children demonstrated very high (61.7%) and high (31.7%) levels, while only 6.7% were assessed at a moderate level. A similar pattern was observed for confidence.

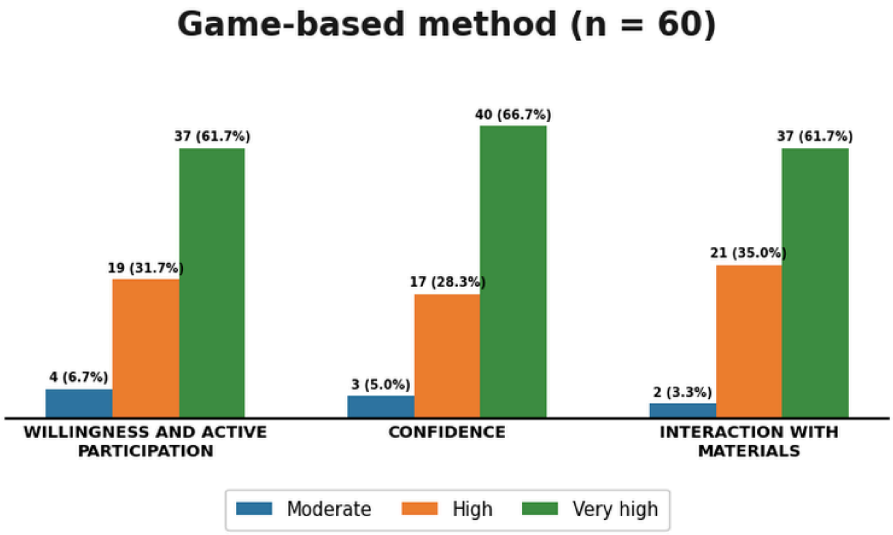


Figure 7. Distribution of assessed indicators for the game-based method (n = 60). Values are presented as n (%). Percentages are rounded to one decimal place and may therefore not sum to exactly 100%.

With respect to interaction with the educational materials, 61.7% of the participants showed a very high level of engagement, 35.0% a high level, and only 3.3% a moderate level. Overall, the game-based method was associated with the highest observed levels of engagement across all three indicators, with a predominance of children classified in the 'Very High' category and few children classified in the 'Moderate' category.

The proportion of children classified in the "Very High" engagement category was used as a descriptive indicator for comparing the distributions across the three educational methods. As each method was evaluated across the same three engagement indicators, the reported values represent the average proportion of children classified in the "Very High" category across the three indicators within each method (Tables 2 and 3).

Table 2. Number and proportion of participants classified as showing "very high" observed engagement across the three indicators.

Engagement Indicator	Interactive	Demonstrational	Game-Based
Willingness	14 (23.3%)	18 (30.0%)	37 (61.7%)
Confidence	14 (23.3%)	19 (31.7%)	40 (66.7%)
Interaction with materials	13 (21.7%)	13 (21.7%)	37 (61.7%)

The descriptive results showed differences in the distribution of observed engagement across the three educational activities. The average proportion of children classified in the "Very High" engagement category was 63.4% for the game-based method, compared with 27.8% for the demonstrational method and 22.8% for the interactive method.

Table 3. Comparison of engagement-related indicators across the three educational methods.

Indicator	Interactive (Mean Rank)	Demonstrational (Mean Rank)	Game-Based (Mean Rank)	Friedman χ^2	p	Post Hoc Comparisons, Bonferroni-Adjusted
Active participation and willingness	1.68	1.84	2.52	57.657	<0.001	I-D: 0.005; I-G: <0.001; D-G: <0.001
Confidence	1.68	1.85	2.58	64.050	<0.001	I-D: 0.001; I-G: <0.001; D-G: <0.001
Interaction with materials	1.58	1.78	2.63	71.048	<0.001	I-D: 0.005; I-G: <0.001; D-G: <0.001

Note: Pairwise comparisons were performed using Wilcoxon signed-rank tests with Bonferroni adjustment; adjusted $\alpha = 0.0167$. Values for the three educational methods are presented as mean ranks from the Friedman test.

The Friedman tests demonstrated statistically significant differences among the three educational methods for active participation and willingness to engage, confidence, and interaction with educational materials (all $p < 0.001$). Post hoc Wilcoxon signed-rank tests with Bonferroni adjustment indicated significant differences between the interactive and demonstrational methods, the interactive and game-based methods, and the demonstrational and game-based methods for all three indicators (all adjusted $p < 0.0167$).

4. Discussion

The results obtained show differences in the children's engagement according to the teaching method used. The highest values were recorded for the game-based method, in which the "very high" rating predominated across all criteria. Particularly pronounced was the willingness to participate—61.7% of the children demonstrated very high willingness to participate. In school-age children, active participation and practical activities may provide opportunities for direct engagement with educational content.

The results obtained are consistent with the data of Wang et al., who found that interactive educational interventions lead to better acquisition of knowledge and skills compared with traditional lecture-based methods [16]. Similar results are reported by Hashemi et al., who demonstrated an increase in self-efficacy and oral health habits following combined teaching approaches [17,18].

Previous research suggests that game-based and interactive approaches may support children's engagement in oral health education [19,20]. The demonstrational method also showed good results, with most children exhibiting a high level of active participation. In the interactive method, the "high" rating predominated, while the proportion of "very high" ratings remained lower than that observed for the game-based approach.

The observed differences in engagement may be related to the active and participatory nature of game-based activities, although the present study did not directly assess the mechanisms underlying these differences. Although previous studies have primarily evaluated knowledge, oral hygiene practices, or clinical outcomes, the present study focused specifically on observed engagement during educational activities. The higher engagement observed during the game-based activity is consistent with previous literature suggesting that game-based approaches may be useful in oral health education; however, the present findings do not allow conclusions regarding subsequent knowledge acquisition, behavioural change, or clinical outcomes [21,22].

The present findings can also be considered in the context of the recent systematic review by Patil et al., which analyzed seven randomized controlled trials involving 1097 children [23]. The review concluded that game-based oral health education was more effective than conventional educational approaches in improving oral health-related knowl-

edge, oral hygiene practices, and clinical oral health outcomes. In contrast, the present study evaluated children's observed engagement, confidence, and interaction with educational materials rather than knowledge acquisition or clinical outcomes. The findings therefore provide complementary evidence regarding children's engagement during oral health education, while further research is needed to determine whether differences in observed engagement are associated with subsequent improvements in knowledge, behaviour, or clinical outcomes.

Game-based methods have been highlighted as particularly relevant in oral health education, as play represents a natural mechanism for learning during childhood. Previous research suggests that game-based activities can make learning a pleasant and emotionally positive experience, potentially enhancing children's intrinsic engagement and participation in the educational process [23]. Game-based approaches have also been described as having the potential to reduce anxiety and tension associated with topics such as dental visits and fear of dental procedures. Role-play, simulations, and the use of imagery may create a safe and supportive environment in which children can express emotions, ask questions, and develop a more positive attitude towards oral health care [23].

Limitations of the Study

The present study has some limitations. The sample is limited to students from a single school and does not include a control group. The assessment was carried out immediately after the training and therefore does not allow for the evaluation of long-term changes in behaviour. Future research should include larger samples and follow-up assessments.

A limitation of the present study is that all participants were exposed to the three educational methods consecutively within a single session. Consequently, the observed outcomes may reflect the cumulative influence of exposure to all three activities rather than the isolated contribution of each method. The sequential order may also have introduced order and carry-over effects, particularly because the game-based activity was conducted last and included educational gifts/prizes that may have provided an additional motivational stimulus. Therefore, the higher engagement observed during the game-based activity should be interpreted cautiously and cannot be attributed solely to the educational method itself. Future studies should use randomized and counterbalanced designs, or separate intervention groups, to reduce these effects.

Another limitation is the use of a study-specific observational assessment framework that was not formally validated as a psychometric instrument. The framework also did not include a 'low' engagement category, which may have truncated the observed distribution and limited the ability to capture lower levels of engagement or disengagement. Therefore, the findings should be interpreted as descriptive observations of behavioural engagement rather than measurements obtained using a validated psychometric scale. In addition, although two trained observers were involved in the study, behavioural ratings were performed by a single observer, and therefore inter-rater reliability could not be assessed.

Accordingly, the evidence generated by this study should be considered preliminary and interpreted with caution. Future research should include larger multicentre studies with longer follow-up periods, validated assessment instruments, independent observers, and different age groups to determine whether differences in observed engagement are reproducible and whether they are associated with subsequent changes in children's knowledge, oral hygiene behaviours, or clinical oral health outcomes.

5. Conclusions

This study should be considered a pilot investigation due to the relatively small sample of participants from a single school. Game-based and demonstrational methods were

associated with higher observed levels of engagement and active participation compared with the interactive approach. The highest levels of observed engagement were recorded for the game-based approach, which may provide a supportive environment for active learning and practical skill development. The findings suggest that game-based educational strategies may warrant further investigation in school oral health promotion programmes.

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Informed Consent Statement: Informed consent was obtained from the parents or legal guardians of all subjects involved in the study. Written informed consent has been obtained from the parents or legal guardians to publish this paper.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author. The data are not publicly available due to ethical and privacy restrictions involving pediatric participants.

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Conflicts of Interest: The authors declare no conflicts of interest.

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