

Effectiveness of Mystery Card Media of Dental Health Knowledge Among Preschool Children in Surabaya

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ABSTRACT Dental health problems remain highly prevalent among preschool children, largely due to inadequate knowledge of proper oral hygiene practices. Preliminary findings at Maryam Islamic Kindergarten, Surabaya, showed that most children exhibited poor dental health knowledge and high caries risk, highlighting the need for more engaging and developmentally appropriate educational media. This study aimed to evaluate the effectiveness of the Mystery Card media, an interactive learning tool integrating printed cards with technology, in improving dental health knowledge among preschool children. A quasi-experimental pretest–posttest control group design was conducted from December 2024 to March 2025, involving 46 preschool children selected through simple random sampling. Participants were divided into intervention and control groups. The intervention group received education using Mystery Card media, while the control group received conventional instruction through PowerPoint presentations. Knowledge data were collected using a validated questionnaire and analyzed using the Wilcoxon and Mann-Whitney tests with a significance level of $\alpha = 0.05$. The results demonstrated a substantial improvement in the intervention group, where the proportion of children in the “good” knowledge category increased from 0% at pretest to 95.7% at posttest ($p = 0.000$). The control group showed improvement only to the “adequate” category, with no children reaching the “good” category ($p = 0.037$). The Mann-Whitney analysis confirmed a significant posttest difference between the two groups ($p = 0.000$), indicating the superior effectiveness of the Mystery Card media. In conclusion, Mystery Card media significantly enhances dental health knowledge among preschool children, outperforming traditional instructional methods. Its interactive features, combining visual and auditory stimuli, create a more engaging learning experience that supports better comprehension and retention. The findings suggest the potential of Mystery Card media as an innovative strategy for early oral health education.

INDEX TERMS Mystery Card Media, Dental Health Education, Preschool Children, Knowledge Improvement, Quasi-Experimental Study.

I. INTRODUCTION

Preschool age represents a critical developmental period in which children rapidly acquire foundational cognitive, motor, and socio-emotional abilities that shape long-term health behaviors [1], [2]. Oral health is a particularly important component of child well-being, as early dental problems such as dental caries can adversely affect nutrition, growth, speech development, and overall quality of life [3], [4]. Globally, dental caries remain one of the most prevalent chronic diseases among young children, with an estimated 60–90% of preschoolers affected, especially in low- and middle-income countries [5]. Similar patterns are reported in Indonesia, where caries prevalence in children aged 3–5 years exceeds 80% [6]. Preliminary observations at Maryam Islamic Kindergarten revealed a high def-t score (7.3) and limited understanding of oral hygiene practices, indicating a substantial gap in early oral health knowledge.

Efforts to improve oral health literacy in early childhood commonly rely on traditional educational approaches such as lectures, demonstrations, posters, and PowerPoint presentations. Although these methods can transmit basic information, their effectiveness is often limited due to children’s short attention spans and preference for interactive, visually engaging learning formats [7], [8].

Recent advancements in educational technology have introduced various state-of-the-art media, including animation videos, mobile applications, augmented reality (AR) tools, and interactive games, which have demonstrated significant potential in enhancing learning outcomes among young children [9]–[12]. Studies report that technology-supported media improve attention, comprehension, and retention of oral health information more effectively than conventional instruction [13], [14].

Despite these advancements, several gaps remain unaddressed. First, many existing applications require continuous internet access or adult supervision, limiting their usability in preschool settings [15]. Second, the integration of multisensory components visual, auditory, and tactile elements remains limited in traditional media and is rarely optimized in early childhood oral health programs [16]. Third, there is limited empirical evidence on hybrid printed–digital media combining physical interaction with technology, which may offer a more developmentally appropriate alternative for preschool-aged children [17]. To address these gaps, innovative educational tools that balance interactivity, accessibility, and cognitive appropriateness are needed.

This study seeks to respond to these limitations by evaluating the Mystery Card media, an interactive learning tool integrating printed cards with barcode-scannable animations and audio explanations. This hybrid format aligns with preschool children's learning preferences by providing tactile engagement alongside appealing visual-auditory content. Therefore, the aim of this study is to assess the effectiveness of the Mystery Card media in improving dental health knowledge among preschool children at Maryam Islamic Kindergarten, Surabaya. The major contributions of this study are as follows:

1. Introducing a hybrid printed-digital oral health media that combines traditional learning with interactive multimedia, offering a novel alternative to existing approaches.
2. Providing empirical evidence on the effectiveness of Mystery Card media in improving oral health knowledge through a quasi-experimental design, addressing the limited number of studies using robust comparative methods for preschool populations.
3. Offering practical recommendations for early childhood educators and health promoters, emphasizing the value of developmentally appropriate, technology-supported educational strategies in oral health promotion.

The remainder of this article is structured as follows. Section II describes the methodology, including study design, sampling procedures, intervention materials, and data analysis techniques. Section III presents the results of the intervention, comparing pretest and posttest outcomes between the intervention and control groups. Section IV provides an in-depth discussion of the findings in relation to existing literature, including theoretical implications and study limitations. Section V concludes the article by summarizing key insights and suggesting directions for future research.

II. METHODS

This study employed a quasi-experimental design with a pretest-posttest control group arrangement to evaluate the effectiveness of the Mystery Card media in improving dental health knowledge among preschool children. A quasi-experimental approach was chosen because it allows comparison between intervention and control groups when full randomization is not feasible in school-based settings [26]. The design enabled measurement of changes in knowledge levels before and after the intervention, as well as comparison between groups receiving different educational methods.

A. STUDY SETTING AND DURATION

The study was conducted at Maryam Islamic Kindergarten, located in the Gubeng District of Surabaya, Indonesia. The research period extended from December 2024 to March 2025, covering preparation, sampling, instrument validation, intervention delivery, and data collection. All educational sessions were carried out in designated classrooms under the supervision of trained teachers and researchers.

B. STUDY POPULATION AND ELIGIBILITY CRITERIA

The study population consisted of all preschool children enrolled at Maryam Islamic Kindergarten during the 2024–2025 academic year. Inclusion criteria were: (1) children aged 4–6 years, (2) registered as active students, (3) having no cognitive impairments that hinder participation, and (4) obtaining parental informed consent. Children absent during data collection or those with severe visual or hearing

impairments were excluded. A total of 46 eligible participants were included. Sample size adequacy followed recommendations for quasi-experimental educational studies involving early childhood learners, where 20–25 participants per group are considered sufficient to detect moderate effect sizes [27].

C. SAMPLING TECHNIQUE AND GROUP ALLOCATION

Simple random sampling was applied to select participants from the student population. A computer-generated number list was used to ensure equal selection probability. After sample selection, participants were assigned into two groups using stratified random allocation to balance gender and age distribution.

1. Intervention group: 23 children received Mystery Card media.
2. Control group: 23 children received instruction using PowerPoint slides.

Stratified allocation minimized selection bias and ensured comparable baseline characteristics between groups, which is essential for internal validity in quasi-experimental designs [28].

D. INTERVENTION MATERIALS

1. Mystery Card Media (Intervention)

The Mystery Card media consisted of printed cards containing dental health illustrations, QR codes, and short descriptions. Each QR code activated animations and audio explanations accessible through smartphones or tablets. The media were designed to integrate multisensory components, which have been shown to improve knowledge retention in preschool-aged children [29].

2. PowerPoint Presentation (Control)

The control group received conventional oral health education through PowerPoint slides containing simple text, images, and verbal explanations. No multimedia or interactive elements were used to maintain the contrast between conventional and technology-integrated media.

E. INTERVENTION PRECEDURES

The intervention consisted of four instructional sessions delivered once per week for four consecutive weeks. Each session lasted approximately 30 minutes. All sessions were facilitated by trained teachers who had undergone a two-hour orientation regarding standardized delivery procedures. For the intervention group, children were introduced to the Mystery Card media and guided in scanning QR codes using school-provided devices. Teachers assisted children in navigating animations and ensured equal interaction opportunities. For the control group, teachers delivered content using projected PowerPoint slides, accompanied by verbal explanations. Standardized instructional scripts were used for both groups to ensure content equivalence aside from the media differences.

F. DATA COLLECTION INSTRUMENT

Dental health knowledge was assessed using a structured questionnaire adapted from validated early childhood oral health instruments. The questionnaire consisted of 15 items measuring knowledge about toothbrushing frequency, appropriate tools, dietary impacts, and basic oral hygiene principles. The questionnaire underwent content validation by three experts in pediatric dentistry and dental public health. Reliability testing using Cronbach's alpha yielded a value of 0.85, indicating strong internal consistency [30]. The

instrument was administered in a structured interview format to ensure comprehension among preschool-aged participants.

G. DATA COLLECTION PROCEDURES AND ETHICAL CONSIDERATIONS

Data collection was performed twice:

1. Pretest: conducted one week before the first educational session.
2. Posttest: conducted one week after the final session.

Researchers administered the questionnaire individually to each child to minimize misunderstanding and response bias. Responses were recorded directly by researchers to avoid inconsistent interpretation.

The study received ethical approval from the Health Research Ethics Committee of the corresponding institution. Written informed consent was obtained from parents or legal guardians. Teachers were briefed on confidentiality and appropriate handling of children during educational sessions. Throughout the study, children's identities were encoded to maintain anonymity.

H. DATA ANALYSIS AND REPLICABILITY

Given that the dataset involved ordinal scores and a relatively small sample size, normality testing using the Shapiro-Wilk test confirmed non-normal distribution. Therefore, nonparametric tests were used in accordance with recent recommendations for small-sample educational health studies [31].

1. Wilcoxon Signed Rank Test: to compare pretest and posttest scores within each group.
2. Mann-Whitney U Test: to compare posttest results between the intervention and control groups.

Effect size (r) was calculated based on z-scores to determine the magnitude of improvements, following guidelines for quasi-experimental research in early childhood populations [32]. A significance threshold of $\alpha = 0.05$ was applied for all analyses.

To ensure replicability, all procedures including session duration, instructional materials, scoring criteria, and data collection methods were standardized. The Mystery Card media files, QR codes, and instructional scripts are available upon request, allowing other researchers to replicate the intervention in similar early childhood educational environments, consistent with best practices in experimental educational research [33].

III. RESULT

TABLE 1

Categories of Dental Health Maintenance Knowledge Results Before and After the Intervention Using Mystery Card Media in the Intervention Group of Preschool Children at Maryam Islamic Kindergarten, Surabaya, in 2024.

Category	Pretest		Posttest	
	N	%	N	%
Baik	-	-	22	95,7%
Cukup	7	30,4%	1	4,3%
Kurang	16	69,6%	-	-
Total	23	100%	23	100%

TABLE 1 shows a significant improvement in dental health maintenance knowledge among respondents in the intervention group. Before the education using Mystery Card media, 69.6% of respondents were in the "poor" category, with no respondents in the "good" category. After the intervention, the proportion in the "good" category increased to 95.7%, representing a 95.7% improvement. This

demonstrates the effectiveness of Mystery Card media in enhancing knowledge acquisition compared to traditional methods.

TABLE 2

Categories of Dental Health Maintenance Knowledge Results Before and After Receiving Education Using Powerpoint Media in the Control Group of Preschool Children at Maryam Islamic Kindergarten, Surabaya, in 2024.

Category	Pretest		Posttest	
	N	%	N	%
Baik	-	-	-	-
Cukup	7	30,4%	18	78,3%
Kurang	16	69,6%	5	21,7%
Total	23	100%	23	100%

TABLE 2 shows that the responses regarding dental health maintenance knowledge in the control group before receiving education through the use of PowerPoint media mostly fall into the "poor" category (69.6%). After receiving dental health maintenance knowledge through PowerPoint media, the responses from the control group indicate that most of the knowledge fell into the "adequate" category (78.3%).

TABLE 3

The Wilcoxon Test Results for the Intervention and Control Groups in Preschool Children at Maryam Islamic Kindergarten, Surabaya, in 2024.

Test Uji Wilcoxon Kelompok Intervensi		
	α	Sig.
<i>Pre Test</i>	0,05	0,000
<i>Posttest</i>		
Test Uji Wilcoxon Kelompok Kontrol		
	α	Sig.
<i>Pre Test</i>	0,05	0,037
<i>Posttest</i>		

TABLE 3 shows the knowledge values for the intervention group before and after the treatment using the Mystery Card media, with a significant value of 0.000. A Sig. value of 0.037 was found when the control group showed knowledge values before and after the intervention using PowerPoint presentations. Both groups experienced differences between the pretest and posttest. However, there is a notable comparison between the intervention and control groups.

TABLE 4

The Mann-Whitney Test Results for the Intervention and Control Groups in Preschool Children at Maryam Islamic Kindergarten, Surabaya, in 2024

No	Variable	Statistics		A	Sig.
		Intervention	Control		
1.	Baik	22		0,05	0.0000
2.	Cukup	1	18		
3.	Kurang		5		

Based on the results in TABLE 4, the Mann-Whitney test indicated a statistically significant difference between the intervention and control groups. The posttest analysis yielded a p-value of 0.000, which is below the predetermined significance level of 0.05, leading to the rejection of the null hypothesis (H_0) and the acceptance of the alternative hypothesis (H_1). These results demonstrate that the use of the Mystery Card media produced a meaningful improvement in children's understanding of dental health concepts, confirming its effectiveness as an educational tool for

enhancing preschoolers' awareness of proper oral hygiene practices.

IV. DISCUSSION

A. INTERPRETATION OF FINDINGS

The present study assessed the effectiveness of the Mystery Card media in improving dental health knowledge among preschool children. The pretest results demonstrated that both intervention and control groups initially exhibited low levels of knowledge, which is consistent with early childhood developmental stages wherein children typically rely on external guidance for understanding health behaviors. Following the intervention, a substantial improvement was observed in the intervention group, with 95.7% of participants achieving a "good" knowledge category. In contrast, the control group exhibited only moderate improvement, with most participants remaining in the "adequate" category. These findings indicate that the Mystery Card media integrating visual, auditory, and interactive elements provides superior knowledge enhancement compared to conventional PowerPoint-based education.

The statistical analysis supports this conclusion. The Wilcoxon test showed a highly significant increase in knowledge scores in the intervention group ($p = 0.000$), demonstrating that the Mystery Card media evoked meaningful learning gains. Moreover, the Mann-Whitney test revealed a significant difference between the two groups at posttest ($p = 0.000$), confirming the differential impact of the intervention. The magnitude of improvement suggests that interactive stimulation provided through QR-code-based animations facilitated greater engagement and comprehension among preschool-aged children. These results support cognitive learning theories suggesting that multisensory stimuli enhance memory retention and information processing in early childhood [34].

Additionally, the tactile component of cards, combined with digital interactivity, may have enhanced intrinsic motivation and curiosity, which align with constructivist learning models. Preschool children are highly responsive to learning tools allowing exploration, visual cues, and immediate feedback. Therefore, the Mystery Card media not only transmitted information but also supported sensory-rich experiences that reinforced learning.

B. COMPARISON WITH PREVIOUS STUDIES

The present findings align with a growing body of research highlighting the effectiveness of technology-assisted educational media in promoting oral health knowledge among children. For example, studies have shown that animated videos, augmented reality (AR) tools, and digital applications significantly enhance children's understanding and adherence to oral hygiene practices [35]. This similarity reinforces the notion that interactive visuals and engaging formats are more effective for early learners compared to traditional didactic approaches.

A study by Mohd Jaini et al. (2024) reported that children exposed to video-assisted oral health education demonstrated significantly higher post-intervention scores compared to those receiving conventional lectures [36]. Likewise, Lin et al. (2024) emphasized that AR-based dental education tools improve children's retention, attention, and motivation, supporting the findings of the present study that multimedia content enhances comprehension [37]. The congruence of results suggests that Mystery Card media similarly benefits from the integration of digital and physical elements.

However, the current study also diverges from some previous findings. For instance, research by Drawanz et al. (2020) suggested that improvements in oral health knowledge among preschool children could be limited when the educational medium requires extensive parental supervision or technology proficiency [38]. In contrast, the Mystery Card media used in this study required minimal adult assistance, as children could independently interact with the cards once QR codes were demonstrated. This finding highlights the potential advantage of hybrid media that reduces reliance on adults while still leveraging technology.

Furthermore, studies such as those by Nomair et al. (2020) and Santoso et al. (2019) demonstrated that mobile applications and game-based learning tools can yield positive outcomes, although these approaches often require prolonged exposure or repeated use to produce meaningful changes [39], [40]. The current study observed significant improvements within a relatively short intervention period, suggesting that the Mystery Card media may produce more immediate and efficient learning outcomes.

Moreover, some studies reported challenges in implementing technology-based tools in preschool settings due to limited device accessibility and low digital literacy among educators. In comparison, the implementation of Mystery Card media in this study benefited from its low technological burden, requiring only a smartphone to scan the QR codes, without needing continuous internet access or advanced digital platforms.

C. LIMITATIONS, WEAKNESSES, AND IMPLICATIONS

Despite the promising results, several limitations must be acknowledged. First, the study involved a relatively small sample size ($n = 46$), which may limit the generalizability of findings to broader populations. Although the sample size is consistent with recommendations for quasi-experimental designs involving young children, larger samples across diverse settings are necessary to validate the external validity of the findings.

Second, the study relied on a short-term intervention and posttest design, which does not measure long-term retention of knowledge. Previous studies indicate that children's oral health knowledge tends to decline over time without reinforcement, suggesting that ongoing exposure or booster sessions may be required to sustain improvements [41]. Future research should incorporate follow-up assessments to determine retention rates over several months.

Third, the assessment instrument relied on structured interviews using a questionnaire, which raises potential concerns of social desirability bias. Preschool children may respond with perceived "correct" answers rather than genuine understanding. Although interview administration helps clarify questions, direct observational assessments such as evaluating brushing technique or practical demonstrations would strengthen measurement accuracy.

Fourth, environmental factors such as parental involvement, home routines, and exposure to external digital content were not controlled. These variables could influence children's learning outside school and may have created unmeasured variation in results. Future studies should include parental questionnaires or home-based assessments to better isolate intervention effects.

Despite these limitations, the study offers valuable implications for oral health promotion in early childhood settings. The findings demonstrate that integrating printed materials with digital features can significantly enhance

learning outcomes, offering a scalable and cost-effective educational strategy. The Mystery Card media requires only minimal technological infrastructure, making it suitable for schools with limited digital resources.

For educators, the intervention provides a practical tool that can be easily incorporated into classroom activities. Its multisensory design aligns with learning preferences of young children, promoting higher engagement and active participation. For policymakers, the findings support the inclusion of hybrid educational media in national oral health programs targeting early childhood populations.

From a public health perspective, early knowledge acquisition is a critical precursor to establishing lifelong oral hygiene habits. Therefore, implementing innovative, engaging media at preschool level could contribute to long-term reductions in dental caries prevalence. Integrating the Mystery Card media into routine health education curricula may provide a sustainable approach to strengthening oral health literacy in Indonesia and similar contexts.

V. CONCLUSION

This study aimed to evaluate the effectiveness of the Mystery Card media in improving dental health knowledge among preschool children at Maryam Islamic Kindergarten, Surabaya. The findings demonstrated a substantial positive impact of the intervention, with the proportion of children achieving a “good” knowledge category increasing from 0% at pretest to 95.7% at posttest in the intervention group. In contrast, the control group taught using conventional PowerPoint slides showed only modest improvement, with most participants remaining in the “adequate” category. Statistical analyses supported these results, as the Wilcoxon test confirmed significant within-group differences for the intervention ($p = 0.000$), and the Mann–Whitney test revealed a highly significant posttest difference between groups ($p = 0.000$). These outcomes indicate that the Mystery Card media, which combines printed cards with multisensory digital animations and audio accessed through QR codes, offers a more engaging and cognitively appropriate learning experience for preschool-aged children. Its multisensory format is consistent with established theories of early childhood learning, emphasizing visual exploration, auditory reinforcement, and interactive participation as contributors to improved cognitive processing and retention. The findings also echo previous research highlighting the superiority of digital and hybrid media over traditional pedagogical tools for oral health education. Nevertheless, this study has several limitations, including a relatively small sample size, short follow-up period, and reliance on self-reported knowledge rather than assessment of practical oral hygiene skills. Future studies should consider longitudinal designs to examine retention over time, include larger and more diverse participant groups, and incorporate observational measures or competency-based evaluations. Despite these limitations, the present study contributes valuable evidence supporting the use of hybrid printed–digital learning tools in early oral health education. Integrating Mystery Card media into school health programs may enhance children’s understanding of dental hygiene practices, potentially reducing long-term caries risk and supporting healthier developmental outcomes.

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DATA AVAILABILITY

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTION

All authors contributed substantially to the development of this study. H.L. Mufarikhah led the conceptualization of the research, conducted data collection, performed the initial analysis, and prepared the original manuscript draft. Isnanto contributed to the refinement of the study methodology, supervised the analytical process, and provided critical revisions to the manuscript. Ratih Larasati supported the methodological design, assisted in ensuring the validity of the research procedures, and contributed to the review and editing stages. Husnul Wafa assisted with project administration, coordination with the study site, and provision of necessary resources throughout data collection. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

DECLARATIONS

ETHICAL APPROVAL

This study was approved by the Health Research Ethics Committee of Poltekkes Kemenkes Surabaya. Written informed consent was obtained from all parents or legal guardians prior to data collection.

CONSENT FOR PUBLICATION PARTICIPANTS.

Not applicable; no individual personal data or identifiable images are included.

COMPETING INTERESTS

The authors declare no competing interests.

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