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Exploring User Needs in the Development of a Gamification-Based Child Oral Health Application Using a User-Centered Design Approach: A Qualitative Study

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Abstract

Background

The demand for health promotion programs targeting healthy populations has increased in recent years. Mobile applications are increasingly used to support disease prevention, risk-factor management, physical activity promotion, dietary improvement, weight management, and reducing smoking, stress, depression, and obesity. The World Health Organization (WHO) defines mobile health (mHealth) as a broad field that uses smartphones, personal digital assistants, wireless monitoring devices, and other mobile technologies to support public health and medical practices. mHealth has the potential to improve healthcare delivery by expanding access to health-related services.

Purpose

This study aimed to identify the theoretical frameworks and adaptive elements to developing an oral health application for children aged 7–9 years.

Methods

This study employs a qualitative method with in-dept interview technique to explore informants' opinions regarding application development. The sampling technique used in this study is purposive sampling. The study sample consisted of six groups: pediatric dentists, psychologists, UI (User Interface) and UX (User Experience) experts, mobile application experts, a parent group, and a children group. The total sample size was 43 individuals.

Results

The participants identified several essential application features, including interactive toothbrushing tutorials, reminders, reward systems, engaging visual elements, personalization, and parental involvement. The HBM constructs were translated into application components through cues to action, feedback mechanisms, and motivational strategies that encourage oral hygiene behaviors.

Conclusion

This study identified critical features for developing a gamification-based oral health application for children aged 7–9 years using the HBM as a theoretical foundation. The findings highlight the importance of interactive education, behavioral reminders, reward mechanisms, personalized experiences, engaging visual designs, and parental support in promoting children's toothbrushing behaviors.

INTRODUCTION

Children are highly vulnerable to dental diseases, particularly dental caries. Virtual oral health education has emerged as an effective approach for improving oral health knowledge and behaviors, with effectiveness comparable to or greater than conventional educational methods.[1,2] However, previous studies have shown that educational interventions delivered by teachers or peers, implemented without audiovisual support, or conducted through classroom-based activities or parental education did not significantly improve dental plaque outcomes.[3] Virtual oral health education continues to gain global attention because it provides flexible access to educational materials and allows learners to review content according to their individual needs.[4]

Recent advances in digital technology have accelerated the development of augmented reality (AR) and mobile augmented reality (MAR) applications in education. A 2022 systematic review reported that AR-based educational interventions improved knowledge retention among patients.[5] Furthermore, research published in 2020 demonstrated that AR and gamification approaches enhanced children's motivation to maintain oral hygiene, thereby supporting dental disease prevention. A 2024 randomized controlled trial (RCT) further showed that MAR-based dental education improved knowledge, self-efficacy, and oral health status among adults in community settings.[6]

The Health Belief Model (HBM) provides a theoretical framework for understanding children's toothbrushing behaviors. The HBM suggests that individuals are more likely to adopt preventive behaviors when they perceive themselves as susceptible to disease, recognize disease severity, understand the benefits of preventive actions, and believe they can overcome barriers to action. Cues to action and self-efficacy also play essential roles in establishing and maintaining healthy behaviors.[7] In oral health promotion, the HBM guides the development of interventions that provide knowledge and encourage children to practice regular, proper toothbrushing.[8,9]

The demand for health promotion programs targeting healthy populations has increased in recent years. Mobile applications have been developed to support disease prevention, risk-factor management, physical activity promotion, dietary improvement, weight management, and reductions in smoking, stress, depression, and obesity.[10–12] The World Health Organization (WHO) defines mobile health (mHealth) as a broad field that uses smartphones, personal digital assistants, wireless monitoring devices, and similar technologies to support public health and medical practices.[29,30] mHealth applications could improve healthcare delivery by expanding access to health-related services.[13]

Mobile applications also facilitate access to dental and oral health services through digital platforms. A 2021 study evaluating smartphone applications for dental caries prevention identified three primary intervention areas: oral hygiene improvement, fluoride use, and dietary management. Most applications focused on improving oral hygiene (92.5%), whereas fewer applications addressed fluoride use (42.5%). The study also identified five commonly used features across both basic and gamified applications: brushing timers, social media connectivity, oral hygiene education, goal setting, and gamification

elements.[14] Evidence from a 2021 study further indicated that gamified applications were more effective than non-gamified applications in reducing dental plaque indices among children.[15]

Although previous studies have evaluated smartphone applications for oral health monitoring and promotion, existing applications have not fully integrated basic monitoring functions with gamification elements for oral health management among children or adults.[9,11,14,16–22] This gap highlights the need to develop applications that combine behavioral theories with engaging digital features to support children's oral hygiene practices.

Therefore, this study aimed to identify the theoretical frameworks and adaptive elements needed to develop an oral health application for children aged 7–9 years. This study also explored the application features and design elements needed to motivate children to brush regularly. Furthermore, this study examined how gamification principles and the Health Belief Model (HBM) could be integrated into the application design to influence children's risk perceptions and motivation to maintain oral hygiene.

MATERIALS AND METHODS

This research received ethical approval from the Ethics Committee of the Faculty of Dentistry, University of Indonesia, under No. 51/Ethical Approval/FKGUI/VIII/2025, Protocol No. 070780725.

Research Sample

Purposive sampling was employed to identify and select individuals or groups possessing specific knowledge or experience relevant to the research phenomenon.[23] Participants provided detailed and reflective accounts of their experiences and perspectives.[23,24] Data collection involved in-depth interviews, initiated by a questionnaire distributed via Google Forms to assess willingness to participate as informants. The questionnaire was disseminated through WhatsApp groups targeting parents and children aged 7–9, psychologists, pediatric dentists, UI/UX experts, and application specialists. All prospective informants received a link to complete an informed consent form before accessing the questionnaire. The total sample size was 43 individuals, with consisting of 9 pediatric dentists, 7 psychologists, 7 mobile application experts, 5 UI/UX experts, 7 parents, and 8 children.

Locations

The research involving psychologists, pediatric dentists, UI/UX experts, and mobile applcaition specialists was conducted online. Research with parents and children aged 7 to 9 years was conducted on-site at an elementary school in Bandung.

Data Collections

In-depth interviews were conducted by the first author, a general dentist, to explore each group's experiences and perspectives regarding the application under development. A basic interview guide was created in consultation with all authors. The interview questions were tailored to the expertise of each group. Participants' responses were further examined through clarifying and exploratory questions, including prompts such as 'Can you tell me more?' or 'What do you think?'.

Interviews were conducted over five months, from November 2025 to March 2026. Data collection ceased when subsequent interviews began to replicate previously obtained information. All interviews were audio-recorded and transcribed verbatim by the first author. The number of informants in each group was determined by data saturation. Sample adequacy was assessed primarily by data depth and saturation, defined as the point at which additional data collection failed to yield new themes.

Data Analysis

Transcribed data were organized and processed using NVivo 12 and analyzed through an inductive qualitative content analysis approach. The analysis followed several stages. Initially, transcripts were read repeatedly to gain a comprehensive understanding and to identify units of meaning related to the role of dental health professionals in health promotion. A unit of meaning consists of words, sentences, or paragraphs interconnected through content and context. Each unit was summarized to retain the core content and then coded. Codes were compared to identify differences and similarities, and those with similar content were grouped into categories and subcategories. A theme represents a common thread of meaning that runs through a category at an interpretive level. During the analysis, the first author identified initial codes, categories, and themes, which were subsequently discussed with all authors until consensus was achieved.

RESULTS

Pediatric Dentist (Pedodontist) Group

Terdapat The pediatric dentist group comprised nine practicing pediatric dentists who expressed interest in simple or gamified applications for promoting children's oral health. Thematic analysis of the interview data identified five key themes: (1) school involvement, (2) personalization, (3) reward systems, (4) toothbrushing tutorials, and (5) minimal data usage.

The first theme concerned school involvement. Participants consistently emphasized the importance of collaboration with the School Dental Health Unit (SDHU) to support regular monitoring and follow-up of children's oral health.

"...every six months, for example, a SDHU doctor might notice the item is still there and follow up through the application...."

"...if you help children get used to these routines at school, it will really benefit them. For example, with SDHU at school, you can send reports to their parents and provide feedback as well...."

The second theme concerned application personalization. Participants suggested adapting application features to individual characteristics and preferences, including gender.

…for example, when it comes to games, girls might like things like princesses or ballet, while boys might prefer shooting games…

Participants also recommended accommodating children who are left-handed or use electric toothbrushes.

…there's a choice to show if the child is left-handed or not. Then there's a choice about whether the child usually uses an electric toothbrush or not…

The third theme concerned reward systems. Pediatric dentists suggested providing rewards after children completed toothbrushing activities through the application. Participants considered digital stickers a potential strategy for reinforcing children's motivation to brush their teeth.

…so there's a sense of achievement, something is accomplished, and there's a prize or reward involved, which gives them extra motivation to do it…

Participants also suggested providing access to games as an additional reward after toothbrushing.

…so, for instance, there's a feature where, once you've brushed your teeth, you can choose to play games…

The fourth theme concerned toothbrushing tutorials. Participants preferred tutorials that provided clear guidance on brushing duration, frequency, and the sequence of tooth surfaces to be brushed.

…ideally, the timer would be paired with a visual showing exactly which area needs to be brushed. Right now, we're only aware of the two-minute timer. It would be great to have an image, like showing the upper right side that needs brushing, alongside the timer…

Overall, pediatric dentists viewed a children's oral health application as both an educational resource and a motivational tool. Participants emphasized integration with school-based dental health programs to support monitoring and follow-up. They also highlighted personalization according to children's individual characteristics, including dominant hand and toothbrush type. Reward systems, such as digital stickers and access to games, were perceived as useful for supporting children's motivation and adherence to regular toothbrushing. Participants also favored interactive toothbrushing tutorials that combined visual guidance with timers and clear information on brushing duration and frequency. Overall, they preferred an application that was simple, engaging, accessible, and responsive to children's and parents' needs.

Psychologists Group

The psychologist group comprised seven practicing psychologists with an interest in simple or gamified applications for children's oral health. Thematic analysis identified seven themes: (1) personalization, (2) parental involvement, (3) habit formation, (4) motivation for toothbrushing, (5) toothbrushing reminders, (6) toothbrushing tutorials, and (7) engaging visuals.

The first theme concerned personalization according to the child's developmental stage. Participants emphasized that application content and rewards should remain appropriate to the child's age to maintain engagement.

"...it has to be personalized. Yes, over time they will probably feel, oh it's not suitable for me, this is too childish and so on. The reward system also needs to be adjusted to the age characteristics..."

The second theme concerned parental involvement. Most participants emphasized that parents play an important role in shaping children's toothbrushing habits. Participants also described parents as behavioral role models whose own oral hygiene practices could influence children's behavior.

"...if children are asked to brush their teeth diligently but their father and mother don't do it, children will question this value. They may think, "Why should I do this if my parents don't?..."

"...parents should also continue to work together with them to improve their teeth so that they will see that the modeling from parents is what is really needed..."

The third theme concerned habit formation. Participants emphasized that consistent toothbrushing routines could help children develop regular oral hygiene behaviors over time.

"...children are accustomed to brushing their teeth after eating and before going to bed. Day after day this behavior will be connected until it becomes an automatic pattern..."

The fourth theme concerned strategies for motivating children to brush their teeth. Participants proposed a reward-and-feedback system that could include animations of healthier and whiter teeth, digital stickers, points, or access to additional game features. Participants described the negative-feedback component as educational rather than punitive. When children failed to record toothbrushing for several consecutive days or did not brush twice daily, the application could display visual consequences such as plaque accumulation, dull-looking teeth, or animated signs of dental caries.

…If, for instance, you aren't diligent, you might end up with a lot of dental issues, like pain, or teeth that become brittle and prone to decay, or teeth that grow in crooked. Explaining cause-and-effect like that might resonate more with them compared to younger children…

The fifth theme concerned toothbrushing reminders. Participants suggested using application notifications to support regular toothbrushing. However, they emphasized that parental involvement remained necessary to ensure that children responded appropriately to these reminders.

"...so remind me, come on, the application is already on, which is a sign that they need to brush their teeth. Or for example, the application is on, which means they have to check their teeth, for example to the dentist. So there must still be that support if they are notified..."

The sixth theme concerned toothbrushing tutorials. Participants preferred concise and interactive tutorials that combined animation with brief and engaging oral health information.

"...short and interactive. Don't make it too like a school lesson. It could be a short fact, a light quiz, or a short animation about why too much sugar causes cavities..."

The seventh theme concerned engaging visual design. Participants emphasized the importance of colors, animation, child-friendly interfaces, and interactive elements in maintaining children's interest.

…Children are highly drawn to colorful, animated, and interactive visuals. They enjoy learning through animation for instance, when it explains how food enters the body, how cavities form, or the consequences of poor dental hygiene. When presented as an animation using simple language, children can grasp the information more easily without feeling like they are studying…

Overall, psychologists emphasized that a children's oral health application should combine education with behavioral strategies appropriate to the child's developmental stage. Participants identified personalization, parental involvement, habit formation, motivational feedback, reminders, interactive tutorials, and engaging visuals as important design components. They considered parental support particularly important because parents can reinforce toothbrushing routines and model appropriate oral hygiene behaviors.

User Interface and User Experience Expert Group

The UI/UX expert group comprised five individuals with experience in developing applications for children. Thematic analysis identified four themes: (1) clear application flow, (2) dedicated parent accounts, (3) reward systems, and (4) visually appealing design.

The first theme concerned a clear and intuitive application flow. Participants emphasized that the application should prioritize its core functions and allow children to access toothbrushing activities without navigating multiple screens or menu layers.

…for example, the button to start brushing, today’s progress, rewards, and reminders. Avoid making the child navigate through multiple menu layers…

The second theme concerned dedicated parent accounts. Participants recommended providing parents with a separate interface that would allow them to monitor their child's toothbrushing activities and review daily progress.

…parents have a separate account to monitor progress, view habit reports, and grant permission for specific features. Children still feel like they have their own app…

The third theme concerned reward systems. Participants suggested using rewards to maintain children's motivation and reinforce positive toothbrushing behaviors. Proposed rewards included digital stickers, new in-app characters, and unlocked application features. Participants also suggested allowing parents to provide digital rewards through the parent-facing interface.

"...for children, visual rewards are very powerful. For example, collecting stickers, unlocking new avatars, or decorating a character's room. Things like that are often more interesting than regular points..."

The fourth theme concerned engaging visual design. Participants emphasized that visual elements for children aged 7–9 years should remain simple and balanced. They recommended using appropriate font sizes and typefaces while prioritizing visual information over extensive text.

"...don't overcrowd the information. Use short sentences, clear icons, and more visuals than text. If possible, just one screen with one main message..."

Overall, UI/UX experts favored a simple and intuitive application design tailored to children aged 7–9 years. Participants identified a clear application flow, dedicated parent accounts, age-appropriate reward systems, and engaging visual elements as essential design components. They also emphasized reducing information density and prioritizing visual content to facilitate children's understanding and use of the application.

Mobile Application Expert Group

The informant group included five user interface/user experience (UI/UX) experts. Thematic analysis identified five themes: (1) offline functionality, (2) games, (3) parental involvement, (4) screen-time limitations, and (5) engaging visuals.

The first theme concerned offline functionality. Participants suggested that core application features should remain accessible without an internet connection to improve accessibility and minimize mobile data consumption.

"...in my opinion, if possible, most of the features can still be used offline. Because it saves quota and is easier for users to access..."

The second theme concerned games and gamification. Participants recommended incorporating simple interactive quizzes and educational mini-games supported by badges, points, or other rewards. They emphasized that gamification should enhance children's motivation without diminishing the educational purpose of the application.

"...in my opinion, gamification is good for increasing children's motivation. For example, by giving points, badges or simple rewards after completing certain activities. But it must still be maintained so that the educational element is not lost..."

The third theme concerned parental involvement. Participants recommended allowing parents to monitor children's activities through application usage reports and daily toothbrushing records.

"...parents still need to monitor their children's activities. For example, there are application usage reports or reminders for parents..."

The fourth theme concerned screen-time limitations. Participants suggested incorporating features that restrict or remind children about application use to minimize excessive smartphone exposure and reduce the potential for device dependency.

"...the aim of educational applications should be to help form good habits, not make children dependent on gadgets. So perhaps the use of applications can be limited or there are screen time settings..."

The fifth theme concerned engaging visual elements. Participants emphasized that attractive colors, recognizable icons, and simple animations could help maintain children's interest in the application.

"...visual appearance is also important, for example bright colors, easily recognizable icons, and simple animations so that children are more interested in using the application..."

Overall, participants emphasized that an effective children's oral health application should combine accessibility, educational content, and engaging features while supporting parental monitoring. Offline functionality, gamification, visual design, and screen-time controls were considered important components. Participants also emphasized that the application should prioritize its core educational and behavioral functions while minimizing the risk of excessive smartphone use.

Parent Group

The parent group comprised seven parents of primary school students aged 7–9 years, including six mothers and one father. Thematic analysis identified three themes related to parents' perspectives on the application: (1) reminder notifications, (2) toothbrushing tutorials, and (3) engaging visuals.

The first theme concerned notifications that reminded children to brush their teeth. Participants considered reminders important for supporting regular toothbrushing.

…reminders are important. So, there are notifications: ‘Have you brushed your teeth today?

The second theme concerned toothbrushing tutorials. Participants expected the application to demonstrate appropriate toothbrushing techniques because children may not always brush their teeth correctly.

…the tutorial. Because children sometimes brush their teeth the wrong way. So, it would be better to have a tutorial…

The third theme concerned visual content. Participants indicated that movement and visual elements could make the application more appealing to children.

"...children prefer things with movement and visuals..."

Overall, parents favored a simple and user-friendly oral health application that could support regular toothbrushing. They identified reminder notifications, toothbrushing tutorials, and engaging visual elements as important features for maintaining children's interest and supporting their understanding of appropriate toothbrushing techniques.

Children Group

The children's group comprised eight elementary school students aged 7–9 years, including four boys and four girls. Thematic analysis identified four themes reflecting children's perspectives on the application: (1) animated videos, (2) notifications, (3) rewards, and (4) toothbrushing tutorials.

The first theme concerned animated videos. All participating children expressed a preference for a toothbrushing application that included animated video content.

..I like watching videos that feature cartoons.

The second theme concerned notifications. Children viewed notifications as useful reminders that could help them remember to brush their teeth.

…there’s a notification for it. Mom said so I wouldn’t forget…

The third theme concerned digital rewards. Children expressed interest in receiving rewards such as coins or game vouchers after completing toothbrushing activities.

…if you’re diligent, you can earn coins…

The fourth theme concerned video-based toothbrushing tutorials. Most participants expressed interest in videos that demonstrated appropriate toothbrushing techniques.

Overall, children expressed interest in oral health applications that incorporated visual and interactive elements, particularly animated videos, reminder notifications, digital rewards, and video-based toothbrushing tutorials. Children perceived these features as enjoyable and useful for remembering toothbrushing activities and learning appropriate toothbrushing techniques.

DISCUSSION

This study examined the perspectives of key stakeholder groups involved in developing a gamification-based oral health application for children aged 7–9 years. The stakeholders included pediatric dentists, psychologists, user interface/user experience (UI/UX) experts, parents, and children. The findings indicate that an effective oral health application should extend beyond information delivery. The application should integrate educational content, habit-formation strategies, motivational features, feedback mechanisms, personalization, parental involvement, and age-appropriate UI/UX design.

A recurring theme across stakeholder groups was the need for toothbrushing tutorials. Pediatric dentists, psychologists, parents, and children all emphasized the importance of tutorials that support proper toothbrushing techniques. However, each group prioritized different tutorial characteristics. Pediatric dentists emphasized information on brushing duration, frequency, and specific areas of the mouth. Psychologists and parents preferred tutorials that were concise, interactive, and easy to understand. Children favored tutorials delivered through videos or animations.[25]

These findings suggest that the educational function of the application should emphasize practical learning experiences rather than passive information delivery. Animation, illustrations, and visual guidance can translate abstract oral health concepts into more concrete learning experiences. This approach is particularly relevant for children aged 7–9 years, who may understand health information more effectively when it is presented through visual representations and interactive activities.[26]

The strong preference for toothbrushing tutorials also supports their role as cues to action within the Health Belief Model (HBM). In the HBM, cues to action refer to internal or external stimuli that trigger the initiation of health-related behavior.[27] A tutorial presented when a child is about to brush their teeth may function as both a behavioral prompt and a source of procedural guidance. In this way, the application can provide support at the moment the target behavior is performed rather than merely delivering health information in advance.[28]

Gamification and reward systems may further reinforce desirable toothbrushing behaviors by providing immediate feedback and recognition. Parental involvement may strengthen this process by supporting monitoring, encouragement, and behavioral modeling. Personalization can further adapt these features to individual users' characteristics, preferences, and needs. Together, these elements illustrate how HBM constructs can be translated into specific and user-centered application features.[29,30]

The integrated findings indicate that the proposed application should include several core components: visual toothbrushing tutorials, reminder notifications, reward systems, adaptive educational feedback, personalization, parental involvement, and a simple, age-appropriate interface.[30] Together, these components address the educational, motivational, behavioral, and usability needs identified by the stakeholder groups.

CONCLUSION

This study identified key features for developing a gamification-based oral health application for children aged 7–9 years using the Health Belief Model (HBM) as a theoretical framework. The findings highlight the importance of interactive toothbrushing tutorials, reminder notifications, reward systems, engaging visual elements, personalization, and parental involvement. The HBM can inform application design through cues to action, behavioral feedback, and motivational mechanisms. A user-centered, theory-driven, and age-appropriate design approach may therefore support the development of applications that promote regular toothbrushing and improve children's oral health behaviors.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the relevant guidelines and regulations. The Ethics Committee of the Faculty of Dentistry, University of Indonesia, approved the study (registration number No. 51/Ethical Approval/FKGUI/VIII/2025, Protocol No. 070780725). All participants received oral and written information about the study, voluntary participation and confidentiality. To obtain approval for children's participation, the informed consent was sent to the parents through school administrators. On the day of the interview, all children who provided the signed informed consent were included in the study.

Consent for publication

Not applicable

Data availability

Data is provided within the manuscript.

Competing interest

All authors declare no competing interests.

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