



Development and Evaluation of a Hygiene Learning Game for Kindergarten Children

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Abstract

Improving clean and healthy living habits in early childhood is important because many young children still need structured support to practice daily hygiene routines consistently. This study aimed to develop and evaluate a digital learning game, *Hygiene Hero: Clean Up Buddies*, for kindergarten children aged four to six years. The study used a design and development approach with a prototyping model and evaluated the game through a one-group pre-test–post-test design and usability assessment using an adapted System Usability Scale. The findings showed that the game helped improve children’s hygiene knowledge and achieved high usability, indicating that the interface was appropriate and acceptable for young learners. The game was developed from classroom observations and teacher input so that the learning activities matched hygiene practices already introduced in kindergarten. This study contributes to early childhood education by showing that digital games designed around authentic classroom hygiene routines and refined through iterative feedback can serve as effective complementary media to support hygiene learning and reinforce healthy habit formation.

Keywords: *digital educational game, early childhood hygiene, interactive learning media, prototyping, usability*

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Introduction

Preventable health problems related to poor hygiene practices remain a significant concern among young children. Empirical evidence consistently shows that inadequate hygiene behavior is associated with increased risk of infectious diseases. A cross-sectional study in Myanmar reported that children under five living in households with limited hygiene practices had a significantly higher prevalence of diarrheal disease compared to those with adequate hygiene facilities (Soe et al., 2024). Similarly, research in Indonesia found that handwashing with soap (HWS) was statistically associated with diarrhea incidence among toddlers and was identified as a significant determinant of diarrheal cases in the study area (Safaryna et al., 2024). In addition, poor personal hygiene behaviors such as inadequate handwashing and nail cleanliness have been linked to Soil-Transmitted Helminth (STH) infections among school-aged children (Afandi et al., 2025). These findings suggest that hygiene behavior plays an important role as a determinant of children’s health outcomes rather than merely functioning as a daily routine.

In early childhood education, clean and healthy living behaviors must be formed at an early age to establish sustainable habits. Studies in Indonesian early childhood settings indicate that children’s awareness and consistency in practicing hygiene routines still require structured reinforcement and educational support (Kasmianti, 2023; Windarta, 2021). Preliminary classroom observations conducted in this study indicate that preschool children often forget to wash their hands before eating, do not brush their teeth properly, and tend to neglect environmental cleanliness unless repeatedly reminded by teachers. These realities highlight the urgency of designing hygiene education strategies that go beyond verbal instruction and promote active habit formation.

Children aged 4–6 years are typically in the preoperational stage of cognitive development, which is characterized by symbolic thinking and learning through concrete experiences, as described in Piagetian developmental theory (Khotimah & Agustini, 2023). From a psychosocial perspective, this age range corresponds to Erikson's stage of initiative versus guilt, during which children begin developing autonomy, responsibility, and early self-regulation skills (Berk, 2013). Therefore, hygiene education at this developmental stage must be delivered through interactive, experience-based learning approaches that align with children's cognitive and psychosocial characteristics.

Game-based learning has been widely recognized as an effective pedagogical strategy in early childhood education. Interactive learning media and educational games have been shown to enhance engagement, motivation, and active participation among young learners (Candra & Rahayu, 2021; Putri & Fadlilah, 2023). A meta-analysis by Alotaibi (2024) reported that game-based learning in early childhood education produces moderate to large effects on cognitive outcomes and learner engagement when aligned with learning objectives. Furthermore, de Freitas (2018) emphasizes that educational games are effective learning tools when systematically designed and pedagogically grounded.

In the field of health education, digital and game-based interventions have also demonstrated positive outcomes. Randomized and quasi-experimental studies indicate that interactive digital games significantly improve children's oral hygiene knowledge and practices compared to traditional teaching media (Azarys et al., 2024; Kumar K et al., 2022). In Indonesia, hygiene-themed educational games and digital applications have been developed to support children's personal hygiene learning (Amalia et al., 2020; Latif et al., 2023; Nurcholis et al., 2017). These studies confirm the potential of digital media to facilitate hygiene education.

However, several research gaps remain. First, several existing digital hygiene learning products tend to present general health content without explicitly grounding the material in authentic daily hygiene routines practiced in kindergarten settings, such as washing hands before meals, brushing teeth after eating, sorting waste, and cleaning classroom spaces. Second, prior studies have implemented structured software development methodologies, including Unified Modeling Language (UML)-based design and Software Development Life Cycle (SDLC) models (Latif et al., 2023; Nurcholis et al., 2017). While these approaches provide systematic technical development procedures, detailed reporting of iterative refinement based on direct feedback from teachers and observations of young children as primary users has received comparatively less emphasis. Third, standardized usability evaluation is not consistently reported, even though usability significantly influences children's ability to interact effectively with digital learning tools. The System Usability Scale (SUS) has been widely validated across digital applications, including digital health systems (Hyzy et al., 2022), yet its application in hygiene-focused digital learning games for early childhood education remains relatively limited.

Based on these gaps, there is a need for research that integrates the development of a hygiene-focused digital learning game grounded in real kindergarten routines, an iterative prototyping process involving teachers and children, and a combined evaluation of both learning outcomes and usability using a recognized measurement instrument. Such integration is essential to ensure that digital hygiene education is pedagogically meaningful, developmentally appropriate, and practically usable by young learners. Therefore, this study aims to develop and evaluate a digital learning game entitled "*Hygiene Hero: Clean Up Buddies*" for kindergarten children aged 4–6 years using a prototyping approach. Specifically, this study seeks to: (1) describe the iterative development process through the phases Listen to Customer, Build/Revise Prototype, and Customer Test Drives Prototype; (2) examine the effect of the game on children's hygiene knowledge using a pre-test and post-test design; and (3) evaluate the usability of the game using the System Usability Scale (SUS) with teacher assistance. The novelty of this study lies in the explicit alignment of the game design with authentic classroom hygiene routines, the integration of user-centered prototyping with learning evaluation, and the simultaneous assessment of both learning effectiveness and usability within an early childhood education context.

Methodology

This study employed a design and development research approach using a prototyping model to develop and refine the digital learning game *Hygiene Hero: Clean Up Buddies* for kindergarten children. The prototyping approach was selected because it enables iterative development in which system requirements and features can be refined through continuous interaction with users (Tanaga & Oetama, 2023). Through this approach, feedback from the school principal and classroom teacher, as well as observations of children's interactions during early trials, can be incorporated into successive prototype revisions to improve both the educational content and usability of the game. In addition to the development process, a quantitative pre-

experimental design using a one-group pre-test–post-test structure was applied to evaluate the effect of the game on children’s hygiene knowledge. This design allows the measurement of knowledge change by comparing children’s scores before and after interacting with the developed game.

The participants were 19 kindergarten children enrolled in the second-year class at TK Sultan Agung, a private kindergarten located in Sleman, Yogyakarta, Indonesia, during the 2025/2026 academic year. The participants consisted of eight boys and eleven girls aged between 4 and 6 years. Based on age distribution, the class included one child aged four years, three children aged five years, and fifteen children aged six years. The class was selected using convenience sampling based on the school’s willingness to participate and the principal’s recommendation. All activities were conducted during regular classroom hours with the presence of the classroom teacher and the researcher.

The development process followed three main phases of the prototyping model: Listen to Customer, Build/Revise Prototype, and Customer Test Drives Prototype. These stages allow iterative refinement of the system through continuous interaction between developers and users. The overall development stages are illustrated in Figure 1 (Pressman & Maxim, 2019).

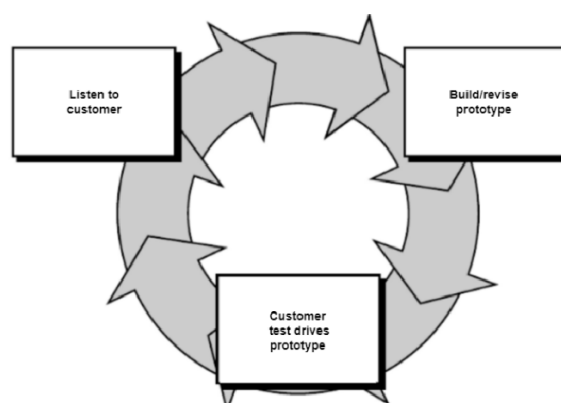


Figure 1. Prototyping stages of the development of the *Hygiene Hero: Clean Up Buddies* game

In the Listen to Customer phase, the researcher conducted classroom observations and semi-structured interviews with the school principal to identify existing hygiene learning practices and the specific needs of kindergarten students. Observations revealed that hygiene routines commonly taught in the classroom include toothbrushing, handwashing before eating, tidying toys, cleaning the classroom, and sorting waste. The school principal also reported that maintaining consistent hygiene habits remains challenging because children often forget routines and require repeated reminders. Based on these findings, the core learning content and gameplay scenarios were designed to reflect daily hygiene practices commonly performed in kindergarten.

In the Build/Revise Prototype phase, the initial prototype of the game was designed using Figma to create the user interface layout and gameplay flow. The prototype was subsequently implemented in the Unity game engine as a two-dimensional educational game. The development process followed an iterative prototyping approach, in which design improvements were made based on feedback obtained from teachers and early prototype trials. Throughout the development process, three main prototype iterations were conducted to progressively refine the interface design, visual elements, and audio components of the game. Each iteration involved revising the prototype based on user feedback and testing the updated version before proceeding to the next revision cycle. Detailed outcomes of these iterative revisions are presented in the Results and Discussion section.

In the Customer Test Drives Prototype phase, the revised prototype was implemented in the classroom environment. During the main implementation session, each child played the game individually using the available devices for approximately fifteen minutes under the supervision of the classroom teacher and the researcher. Prior to the main session, children had observed a short demonstration of how to play the game during earlier classroom visits so that they would become familiar with the interface and controls.

Three main instruments were used in this study: a hygiene knowledge test, the System Usability Scale (SUS) questionnaire, and semi-structured interviews. The hygiene knowledge test was designed to measure children’s understanding of key hygiene practices presented in the game. The test consisted of ten multiple-choice items with two answer options for each. The questions were written using simple language and accompanied by clear cues appropriate for early childhood comprehension.

The same set of items was used for both the pre-test and the post-test, with the order rearranged in the post-test to minimize recall bias. Each correct answer was scored as 10 points and each incorrect answer as 0

points, resulting in a total score range of 0–100. The test blueprint was developed based on six main hygiene topics presented in the game levels: bathing, toothbrushing, tidying toys, disposing of rubbish properly, cleaning the classroom, and washing hands before eating. The distribution of test indicators is presented in Table 1.

Table 1. Blueprint of Hygiene Knowledge Test

No	Hygiene Topic	Indicator	Number of Items
1	Personal cleanliness	Identifying correct bathing habits to keep body clean	2
2	Toothbrushing	Understanding the importance and recognizing correct toothbrushing habits	2
3	Toy organization	Identifying activities to do to toys after playing	1
4	Classroom cleanliness	Identifying activities that keep the classroom clean	2
5	Waste management	Importance of putting waste in the correct bin	2
6	Handwashing	Washing hands before eating	1
Total			10

The content validity of the test items was determined through expert evaluation by the classroom teacher. The validation process focused on evaluating the relevance of each item to kindergarten hygiene routines, the clarity of language for children aged 4–6 years, and the appropriateness of item difficulty. Based on this review, minor revisions were made to the wording of several items to improve clarity and ensure that the questions were easily understood by young children. The internal consistency of the test instrument was assessed using Cronbach's alpha based on the test responses. Reliability analysis was conducted to examine the consistency of the ten-item instrument designed to measure children's understanding of hygiene practices.

The second instrument was the System Usability Scale (SUS), used to evaluate the usability of the developed game. The SUS consists of ten statements rated on a five-point Likert scale (Brooke, 1996). Because the participants were young children, the questionnaire was adapted into simplified Indonesian language and supported by facial icons representing different response levels. Children who were able to read completed the items independently, while younger children selected their responses after the researcher or teacher read or explained each statement.

The SUS score for each participant was calculated using the standard scoring procedure (Sauro & Lewis, 2012). For positive items, the response value minus one was calculated, whereas for negative items, five minus the response value was used. The sum of the adjusted scores was then multiplied by 2.5 to produce a usability score ranging from 0 to 100. In addition to quantitative instruments, semi-structured interviews with the classroom teacher and informal conversations with children were conducted to obtain qualitative feedback about the game. These discussions explored aspects such as visual appearance, sound clarity, ease of use, and children's perceived understanding of the hygiene content.

The overall research procedure followed the sequence of the prototyping model. The study began with classroom observations and interviews to identify hygiene learning needs. The game prototype was then designed and iteratively revised through several development cycles. After the prototype reached a stable version, the game was implemented during regular classroom activities. Children first completed the hygiene knowledge pre-test, then played all six levels of the game individually, and finally completed the post-test and SUS questionnaire with assistance when necessary.

The collected data were analyzed using descriptive and inferential statistical techniques. Pre-test and post-test scores were calculated on a scale from 0 to 100, and the mean scores as well as individual gain scores were computed to describe changes in knowledge. Normality of the score distribution was examined using the Shapiro–Wilk test. Because the data did not meet the assumption of normal distribution, the Wilcoxon signed-rank test was used as the primary statistical method to evaluate differences between pre-test and post-test scores. SUS scores were interpreted using commonly reported usability benchmarks to describe the overall usability level of the system (Bangor et al., 2008).

Ethical considerations were addressed throughout the study to ensure the protection and well-being of all participants. The research was conducted with official permission from the Informatics Study Program, Universitas Islam Indonesia, and the participating kindergarten. Institutional consent was obtained from the school principal and the classroom teacher prior to data collection. The study was conducted during regular lesson hours. Children's data were treated anonymously by reporting only age and gender in the analysis, while individual identities were not recorded or disclosed. These procedures were intended to ensure that the study was conducted in an ethically appropriate manner for classroom-based research involving young children.

Results and Discussion

Development of the Hygiene Hero Game

The development of the digital learning game “*Hygiene Hero: Clean Up Buddies*” followed the three phases of the prototyping model described in the methodology: *Listen to Customer*, *Build/Revise Prototype*, and *Customer Test Drives Prototype*. The iterative process was conducted through several classroom visits at TK Sultan Agung to ensure that the game content aligned with hygiene routines commonly practiced in the kindergarten environment. During the initial visit in June 2025, the researcher introduced the concept of a two-dimensional educational game designed to support hygiene learning for children aged 4–6 years. The proposed game structure consisted of a main menu, a level selection menu, gameplay instructions, and short quizzes designed to reinforce learning outcomes after each level. The interface structure of the early concept is illustrated in Figure 2.

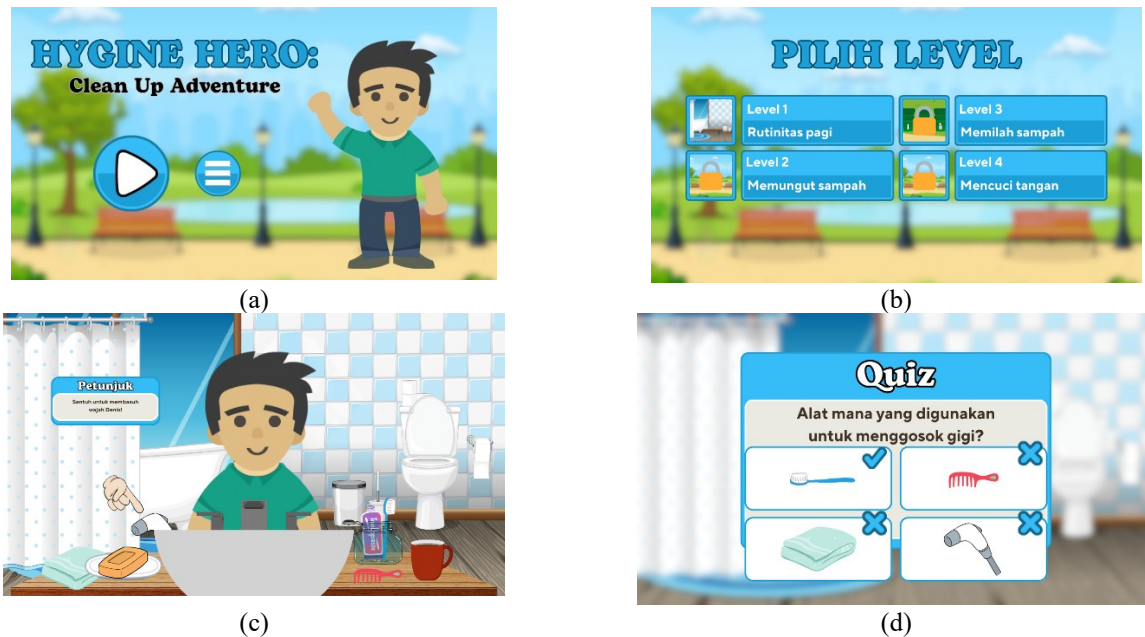
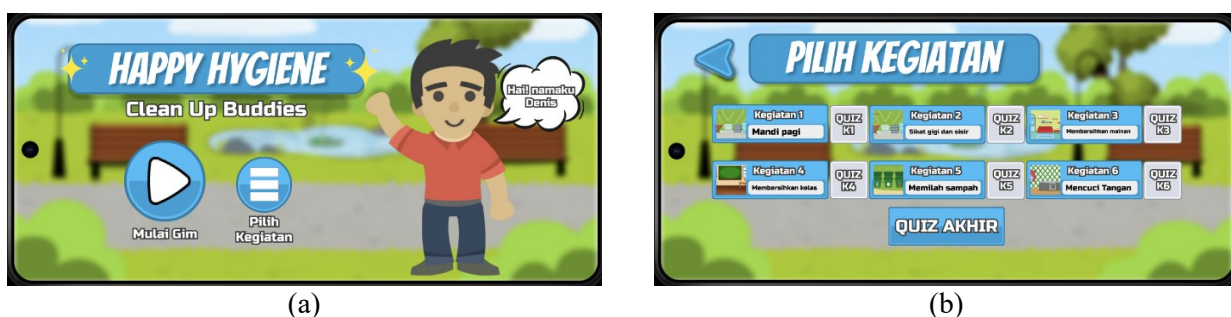


Figure 2. Main interfaces of the Hygiene Hero: Clean Up Buddies game—(a) Main Menu; (b) Level selection; (c) Instruction screen; (d) Quiz screen

Based on discussions with the school principal, the learning content of the game was designed to reflect hygiene activities that children commonly practice in the classroom. Six hygiene scenarios were therefore defined as the core levels of the game: bathing, toothbrushing, tidying toys after playing, cleaning the classroom, sorting waste, and washing hands before eating. Aligning educational content with children's daily routines is important in early childhood learning because children at this age learn most effectively through familiar and concrete experiences (Khotimah & Agustini, 2023). The school principal also recommended using brighter colors to increase the game's visual attractiveness.

Following the initial consultation, an early prototype was designed using Figma to visualize the interface layout and interaction flow. The prototype included the main menu, level selection interface, gameplay scenes for each hygiene activity, and a quiz system designed to reinforce learning. Examples of these interfaces are illustrated in Figure 3. This early prototype was presented to the classroom teacher during the second visit in July 2025.



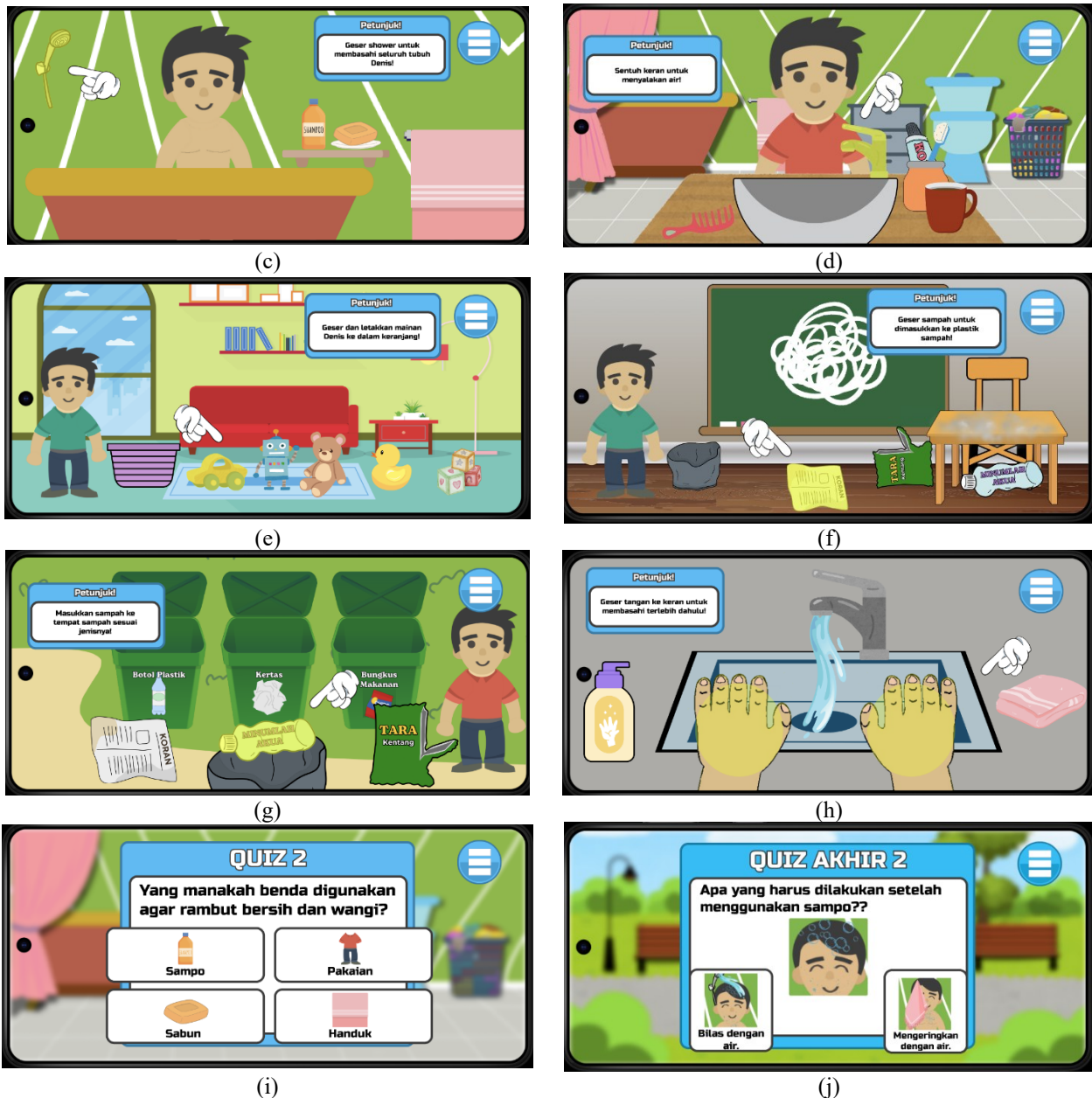


Figure 3. First prototype of the Hygiene Hero game: (a) main menu; (b) level selection screen; hygiene activity levels consisting of (c) bathing, (d) toothbrushing, (e) toy organization, (f) classroom cleaning, (g) waste sorting, and (h) handwashing; (i) quiz after completing a level; and (j) final quiz after completing all levels

After reviewing the prototype, the school principal and the teacher suggested several improvements to make the game more suitable for young learners. These included adding narration and sound effects so that children who were not yet fluent readers could still understand the instructions. Previous research in early childhood learning media emphasizes that audio-visual elements can significantly support children's comprehension and engagement during interactive learning activities (Candra & Rahayu, 2021).

Based on this feedback, the game was implemented using the Unity game engine and enhanced with narration and sound effects. A more complete prototype was presented during the third visit in January 2026. The improved interface of the game after incorporating teachers' feedback is illustrated in Figure 4.

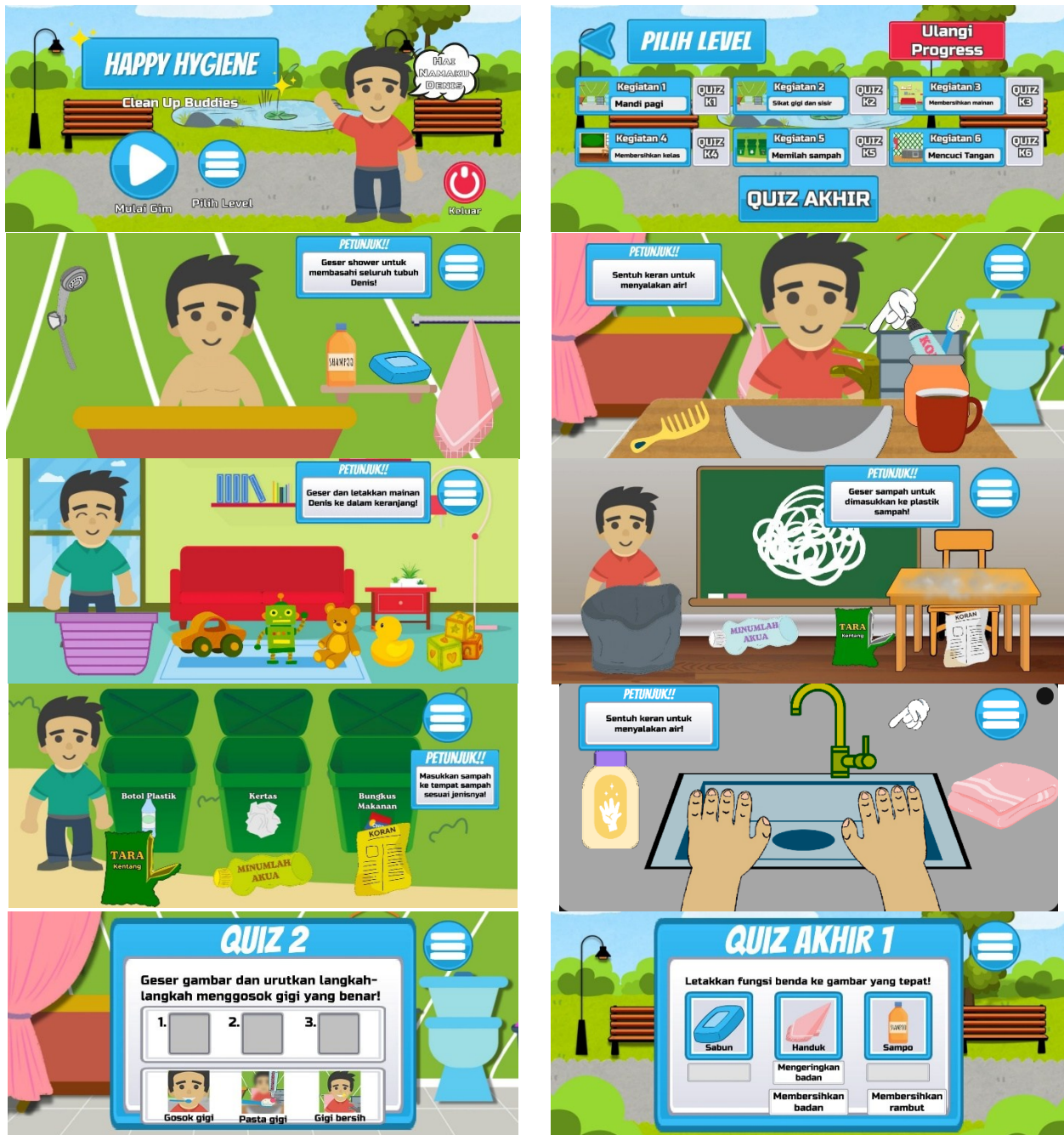


Figure 4. Improved prototype interfaces after incorporating teachers' feedback

During this stage, the teacher considered the game structure appropriate but recommended increasing the narration volume so that the spoken instructions would be clearer than the background music. The audio settings were adjusted accordingly. After these revisions, the game was considered stable and ready for classroom implementation during the fourth visit in January 2026.

The iterative development process demonstrates the importance of incorporating feedback from educators during the design of educational games. Close collaboration with teachers helps ensure that digital learning tools remain pedagogically relevant and developmentally appropriate for young children (Alotaibi, 2024; de Freitas, 2018). Therefore, this user-centered approach ultimately resulted in a more engaging and accessible learning tool.

Effect of the Game on Children's Hygiene Knowledge

The effectiveness of the Hygiene Hero game in improving children's hygiene knowledge was evaluated using a pre-test and post-test design involving 19 kindergarten students. Each test consisted of ten multiple-

choice questions covering the hygiene topics presented in the game. Table 2 presents the individual pre-test and post-test scores of the participating children, including the gain obtained after playing the game.

Table 2. Pre-Test and Post-Test Scores of Children's Hygiene Knowledge

Age	Gender	Pre-Test	Post-Test	Gain	Age	Gender	Pre-Test	Post-Test	Gain
6	Boy	100	100	0	6	Girl	50	90	+40
6	Boy	100	100	0	6	Girl	60	80	+20
6	Boy	80	90	+10	6	Girl	80	90	+10
6	Boy	100	100	0	6	Girl	80	90	+10
6	Boy	90	70	-20	6	Girl	80	90	+10
6	Boy	100	100	0	5	Girl	80	90	+10
4	Boy	90	90	0	6	Girl	90	100	+10
6	Boy	80	80	0	6	Girl	90	100	+10
5	Girl	40	70	+30	6	Girl	100	90	-10
5	Girl	50	80	+30					

Overall, the results indicate an increase in children's hygiene knowledge after interacting with the game. The mean pre-test score was 81.05, while the mean post-test score increased to 89.47, resulting in an average improvement of 8.42 points. This finding is consistent with recent studies reporting that digital games and interactive multimedia can improve children's hygiene and health knowledge compared with conventional media (Amalia et al., 2020; Azarys et al., 2024; Kumar K et al., 2022; Latif et al., 2023; Nurjanah et al., 2025). Although most participants demonstrated improved scores, a few showed decreased post-test scores, which will be further discussed in the final subsection of this section. A summary of the statistical results is presented in Table 3.

Table 3. Summary of Pre-Test and Post-Test Statistical Results

Measure	Value
Number of participants (N)	19
Mean pre-test score	81.05
Standard deviation (pre-test)	18.53
Mean post-test score	89.47
Standard deviation (post-test)	9.70
Mean difference	8.42
Standard deviation of difference	14.25
Wilcoxon Z	-2.63
p-value	0.024

The internal consistency reliability of the hygiene knowledge test was examined using Cronbach's alpha based on the pre-test responses (10 items, N = 19). The analysis produced a reliability coefficient of $\alpha = 0.644$, indicating moderate internal consistency for an exploratory instrument administered to young children. Post-test reliability was not interpreted because the post-test scores became highly homogeneous after the intervention, resulting in very low variance across items.

The difference between the pre-test and post-test scores was analyzed using the Wilcoxon signed-rank test, as the score distribution did not meet the normality assumption. The test results indicate that post-test scores were significantly higher than pre-test scores ($Z = -2.63$, $p = 0.024$), demonstrating a statistically significant improvement in children's hygiene knowledge after interacting with the *Hygiene Hero: Clean Up Buddies* game. Descriptive results also support this finding. As shown in Table 3, the standard deviation decreased from 18.53 in the pre-test to 9.70 in the post-test, indicating that children's understanding of hygiene concepts became more consistent after the intervention. These results suggest that interactive digital games can support children in reinforcing hygiene-related knowledge through engaging visual and experiential learning activities, which aligns with previous studies reporting the effectiveness of game-based learning in improving children's health knowledge and engagement (Alotaibi, 2024; Azarys et al., 2024; Kumar K et al., 2022).

Usability Evaluation Using the System Usability Scale (SUS)

In addition to learning outcomes, the usability of the Hygiene Hero game was evaluated using the System Usability Scale (SUS). The questionnaire was adapted for young children by simplifying the language and adding facial icons representing the response scale. A total of 19 children completed the SUS questionnaire with assistance from the teacher and researcher when necessary. The individual SUS scores ranged from 65.0 to 100.0, with an average score of 88.42. The detailed responses for each SUS item and the calculated scores for all participants are presented in Table 4.

Table 4. System Usability Scale (SUS) Results of The Hygiene Hero Game

Age	Gender	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Score
6	Boy	5	1	5	1	5	1	5	1	5	1	100
6	Boy	5	1	5	1	5	1	5	1	5	1	100
6	Boy	4	2	4	2	5	1	5	1	4	1	87.5
6	Boy	4	2	4	2	5	1	5	1	4	1	87.5
6	Boy	5	1	5	1	5	1	5	1	5	1	100
6	Boy	5	1	5	1	5	1	5	3	5	1	95
4	Boy	5	1	5	1	5	1	4	2	5	1	95
6	Boy	4	1	4	2	4	2	4	1	4	2	80
5	Girl	5	1	5	1	4	1	4	1	4	1	92.5
5	Girl	2	3	2	3	5	1	4	2	5	2	67.5
6	Girl	4	1	3	2	5	1	5	1	5	2	87.5
6	Girl	5	2	4	1	5	1	4	1	5	1	92.5
6	Girl	4	1	4	2	5	2	4	1	4	2	82.5
6	Girl	5	1	5	1	5	1	5	1	5	1	100
6	Girl	4	2	5	2	4	2	5	3	4	1	80
5	Girl	5	2	5	2	4	1	5	2	4	2	85
6	Girl	5	1	5	1	4	1	5	1	4	2	92.5
6	Girl	5	2	4	2	5	2	5	1	5	1	90
6	Girl	3	1	2	2	5	2	3	4	1	1	65
Mean		4.42	1.42	4.26	1.58	4.74	1.26	4.58	1.53	4.37	1.31	88.42

As shown in Table 4, the average SUS score obtained from the 19 participants was 88.42. According to the adjective rating scale developed by (Bangor et al., 2009), a SUS score around 85.5 corresponds to *Excellent* usability, while scores approaching 90.9 fall into the *Best Imaginable* category. Therefore, the Hygiene Hero game can be interpreted as having *Excellent to Best Imaginable* usability, indicating that the children perceived the system as highly easy to use and satisfying. These results demonstrate that the game's interface and interaction design were well accepted by the children during gameplay. The SUS score and its corresponding adjective rating are illustrated in Figure 5.

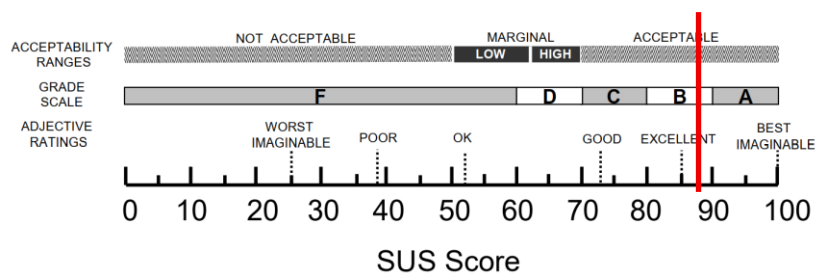


Figure 5. SUS Rating Scale

The high SUS score of 88.42 indicates that the Hygiene Hero game's interface, navigation, and interaction design were highly suitable for the target age group. This level of usability supports user engagement and learning effectiveness, as prior studies have shown that complex or unintuitive interfaces can reduce children's engagement and learning outcomes (Prihadi & Dellia, 2024; Zahra et al., 2025). Consequently, the application proves to be a highly viable digital resource for early childhood settings.

Interpretation of Learning Outcomes and User Feedback

Qualitative feedback obtained from teacher interviews and informal conversations with children helped explain the variation observed in the learning results. According to the classroom teacher, several children who obtained perfect scores in both tests already had good reading ability and were familiar with the hygiene routines taught in the classroom. For these children, the game mainly served as a reinforcement tool rather than introducing entirely new knowledge. Based on interviews, children who showed substantial score improvements reported that the game helped them remember hygiene steps more easily. Some children mentioned that the interactive activities and visual cues helped them understand what actions should be performed in each situation.

However, some variations in the results were also observed. A few children who obtained lower or decreased scores were reported by the teacher to have limited reading ability or to feel tired during the post-test session, which was conducted near the end of the school day. These factors highlight that early childhood learning outcomes may also be influenced by cognitive readiness, reading skills, and classroom conditions during assessment.

Overall, the findings suggest that *Hygiene Hero: Clean Up Buddies* can function as an effective complementary learning medium for hygiene education in early childhood classrooms. Educational games that incorporate familiar daily routines and interactive audiovisual elements can help children understand and remember hygiene concepts more effectively (Darmawan et al., 2024; Lessy, 2024). Furthermore, the iterative prototyping process applied in this study allowed continuous refinement of the game based on feedback from teachers and users. Such collaborative development approaches are recommended in educational game design to ensure both pedagogical relevance and usability (Alotaibi, 2024; de Freitas, 2018).

Despite the positive findings, several limitations should be acknowledged. The study involved a relatively small sample from a single kindergarten, which limits the generalizability of the results. The use of a one-group pre-test–post-test design without a comparison group also limits stronger causal inference regarding the effectiveness of the intervention. In addition, the evaluation focused on short-term knowledge improvement rather than long-term observation of hygiene behavior in daily life. Future research could involve larger samples from multiple early childhood institutions and examine behavioral outcomes over longer periods. Integrating monitoring features that allow teachers or parents to track children’s hygiene learning progress may also enhance the practical application of digital hygiene learning tools.

Conclusion

The *Hygiene Hero: Clean Up Buddies* digital game, developed through an iterative prototyping process, improved kindergarten children’s hygiene knowledge and was perceived as highly usable. Aligning the game content with authentic daily hygiene routines and incorporating audiovisual cues supported children’s understanding, engagement, and consistency in learning. These findings indicate that age-appropriate interactive games can serve as effective complementary tools for hygiene education in early childhood classrooms. Nevertheless, the results should be interpreted in light of the small sample and the use of a one-group pre-test–post-test design in a single kindergarten. Future studies should involve larger and more diverse samples, include comparison groups, and examine longer-term changes in actual hygiene behavior.

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