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Online Game-Based Learning for Hand Hygiene Practices Among Young Children in Indonesia: A Quasi-Experimental Study

Yuri Nurdiantami*
University of Tsukuba
JAPAN

Hilda Agil
University of Tsukuba
JAPAN

Tokie Anme
University of Tsukuba
JAPAN

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Abstract

Hand hygiene remains a cornerstone of infection prevention due to its crucial role in reducing the transmission of infectious diseases across community and healthcare settings. However, establishing consistent handwashing habits among young children remains challenging despite school-based health education programs. Game-based learning has emerged as a promising approach to enhance engagement and support behavior change in early childhood education, yet empirical evidence from developing countries remains limited. This study aims to evaluate the effectiveness of an online game-based educational intervention in improving hand hygiene performance among early childhood children in Indonesia. A quasi-experimental pretest–posttest design was conducted with 50 parent–child pairs involving children aged 4–6 years in Bekasi City. Participants accessed an online educational game designed to teach proper handwashing practices over one week. Baseline and follow-up observations were conducted to assess behavioral change. As the data were not normally distributed (Shapiro–Wilk $W = .97$, $p = .03$), the Wilcoxon signed-rank test was applied. Results showed a significant improvement in hand hygiene scores from pretest (Mdn = 3.0) to posttest (Mdn = 15.0), $Z = -6.034$, $p < .001$, with a large effect size ($r = .60$). These findings support the use of digital games as an effective and innovative learning tool to promote health-related behaviors among young children.

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INTRODUCTION

Post-pandemic, educators must quickly adjust to continual changes in the technological and social environment (Tan et al., 2025; Yusaini et al., 2024). These changes are having an enormous impact on how teachers will deliver health education, especially to young children who will benefit from motivating and age-appropriate ways of learning. One health education topic that continues to be a challenge for preschool students is teaching hand hygiene practices as children of this age group often do not remember the steps of washing their hands properly and need repetition to develop appropriate long-term behaviours.

Hand hygiene to avoid infection in children and decrease the occurrence of disease in the home and in school has been established as a critical behaviour (Khan et al., 2021). Globally, approximately 1.7 billion instances of diarrheal disease occur every year in children under five worldwide, and therefore, it is a leading cause of malnutrition among children in this age group. (WHO, 2017). Studies suggest that using soap when washing hands can reduce the incidence of diarrhea by more than 47% (Curtis & Cairncross, 2003). Data from the Indonesian national health research regarding national handwashing practices with soap in 2018 indicated that the percentage

* **Corresponding Author**
Yuri Nurdiantami, University of Tsukuba, JAPAN ✉ nurdiantamiyuri@gmail.com

of individuals over 10 years old exhibiting proper handwashing behavior remains below 50% (Badan Penelitian dan Pengembangan Kesehatan, 2018). The results reveal that developing proper hand-washing habits at an early age will help reduce possible health risks that could hinder children's growth and development while establishing lifelong healthy lifestyle habits.

The early years of a child's life are critical for developing good hygiene habits that will last throughout their lifetime (Wang et al., 2024). According to behavior theory, children who experience the same routine several times during their early years will develop strong associations with that behavior as well as other healthy behaviors (de Wit & Dickinson, 2009). This makes the promotion of appropriate handwashing at this time imperative for developing long-lasting, healthy habits. Creating clean, healthy living environments at an early age contributes positively to the health of the population, and as such has been shown to be correlated with the financial stability of a country (Joseph, 2022). Research in Indonesia has demonstrated that even though there are health programs established, children are not consistently washing their hands, leading to concerns over ultimate health outcomes (Hirai et al., 2016). The reason this may be happening could stem from limited handwashing facilities, lack of intrinsic motivation to wash hands, absence of peer/family encouragement, etc. Due to this issue, there is a great need for education on hand hygiene to be taught in schools as well as learned at home.

The move toward digital methods of delivering instruction after COVID-19 has created significant challenges related to teaching young children (ages 4-6) health skills, particularly for teaching practical skills such as how to wash their hands properly. Traditional approaches to health education that involve the teacher showing kids how to perform a health-related skill and allowing students to use their hands and feel materials will most likely not work as well in an online environment as they would in a face-to-face environment. Children ages 4-6 often experience difficulty sustaining their attention for long periods of time and lack immediate sensory feedback. (Plotka & Guirguis, 2023).

Furthermore, some challenges faced by Indonesian early childhood educators include that they do not have reliable access to the internet in rural communities, have parents who feel overwhelmed from being temporary facilitators of their children's education, and do not have any play-based learning platforms available for children; therefore, children do not have enough access to different types of educational experiences (Hidayati & Rudiyanto, 2021). The problems presented in this way are compounded: younger students don't want to participate in online courses because they lack the same level of interactivity found in traditional face-to-face classes; also, without having their peers around them, they won't develop the necessary social norms, including learning about good hygiene habits. Therefore, using modern teaching methods in combination with engaging online methods can be an effective method for significantly increasing student performance and providing an avenue for increased student engagement (Graichen et al., 2024). To teach kids about hand washing, there is an increasing amount of need for interactive teaching methods within the classroom environment; one challenge that traditional 'teacher-centred' methods face when it comes to helping kids learn how to wash their hands is keeping their interest, which is something that needs to be fixed (Tidwell et al., 2020).

Recent data indicate that game-based education, encompassing digital games, interactive animations, and feedback-driven learning tools, may enhance children's knowledge, beliefs, and patterns of behavior related to health (Ismail & Sabrina, 2023). The use of digital game-based interventions has improved children's hand-washing practices in terms of the quality and length of time they wash their hands. Digital game solutions also address health behavior problems for preschool-age kids (Graichen et al., 2024; Lagu et al., 2022; Shaluhiyah et al., 2025). The use of play-based interactive tools has helped children to understand germs better and follow good hygiene routines (Younie et al., 2020). Other studies have shown that health education games have improved children's learning outcomes and have the ability to create the most significant effects in health education for both children and adolescents (Ancona et al., 2011). Another review found that digital technologies had been effective in hand hygiene research when used in conjunction with other methods and that digital technologies have been effective in helping with hand hygiene behavior change (Joseph, 2022). Such a trend is consistent with the overall empirical base supporting the view that game-based learning (GBL) is capable of developing learners' motivation, involvement, and participation through the incorporation of goals, challenges, and feedback within

the learning environment, which is likely to enhance significant behavioral and cognitive learning processes (Abdulrahman & Rawf, 2022; Faqih et al., 2021 ; Haryandi et al., 2021; Sari et al., 2025; E. F. N. Sari et al., 2025).

Despite trials in other countries utilizing game-based interventions for the purposes of health education, there is presently a significant lack of evidence from within Indonesia itself, particularly in regard to early childhood settings. Notably, there is a lack of published research assessing the effectiveness of a game-based hand hygiene intervention for young children in Indonesia. As such, there appears to be a gap in the local practice of utilizing digital and play-based health education, as well as in the broader, international literature. Thus, this study aims to evaluate the effectiveness of a digital game-based educational intervention in improving hand hygiene performance among early childhood children in Indonesia. Furthermore, this study introduces an innovative approach by integrating parent–child interaction through a digital platform, thereby bridging the gap between home and school environments and addressing limitations in health education following the COVID-19 pandemic.

METHOD

Study design and participants

A quasi-experimental design study with one group and pretest-posttest was conducted in November 2021 to evaluate the actual use and benefit of an online educational game for typically developing preschool and early primary-aged children aged 4 to 6 years after a one-week intervention.

Data were collected from 50 dyads (from 50 parents and their 4–6-year-old children) using observational techniques within the densely populated city of Bekasi, Indonesia. The sample size determination was predominantly based on practicality, given no published effect size from the Indonesian preschool population for similar interventions. Sample size also adhered to previously established research guidelines for pilot and preliminary research projects. These sample sizes of 30–50 participants are consistently suggested as usable for initial feasibility and preliminary effect of behavioral intervention studies. The inclusion criteria are pairs of healthy parents and children; parents can engage in instructional hand hygiene activities, while children can participate in and understand the games. The exclusion criteria are children who have already played an online handwashing game and children with special needs or disabilities. This study employs a purposive sampling method that reflects constraints on community access during the ongoing pandemic and the need to ensure that participating families have the necessary technological capacity.

The demographic characteristics of the participants are summarized in Table 1. The sample consisted of 50 parent–child dyads, with children aged 4–6 years. Most parents were female (96%) and not formally employed (90%). The majority had completed at least senior high school, and most families reported a monthly income below IDR 4,700,000.

Table 1. Characteristics of Participants (n=50)

Variable	Frequency (n)	Percent (%)
Parent's age		
Mean = 35.30, Median = 34.00, SD = 7.166		
Parent's Sex		
Male	2	4.0
Female	48	96.0
Working status		
Not working	45	90.0
Civil worker	1	2.0
Enterpreneur	1	2.0
Others	3	6.0
Monthly income		
< Rp 4.700.000	33	66.0
≥ Rp 4.700.000	17	34.0

Variable	Frequency (n)	Percent (%)
Last educational attainment		
Elementary school	8	16.0
Junior high school	10	20.0
Senior high school	20	40.0
University degree	12	24.0
Child's age		
4	15	30.0
5	23	46.0
6	12	24.0
Child's sex		
Male	24	48.0
Female	26	52.0

Measurement and instruments

A voice recorder and a video recorder were used for the observations. This study employs two observers, a researcher and a research assistant. The observers worked independently, blinded to participant characteristics, and became familiar with standard WHO hand hygiene steps. Each video was scored using the 11-step checklist. Video recording allowed for repeated viewing and scoring reliability checks. The researcher used observation sheets containing steps for proper hand hygiene to score hand hygiene practices before playing and after 1 week of exposure to the online educational game.

The eleven steps observed were based on WHO guideline (WHO, 2009) as follows: wet hands with water; apply soap to all hand surfaces; rub hands together palm to palm; place right palm over left palm with fingers interlaced and vice versa; rub palms together with fingers interlaced; use the backs of fingers against opposing palms with fingers interlocked; perform rotational rubbing of the left thumb held in the right palm and vice versa; execute rotational rubbing, back and forth, with clasped fingers of the right hand in the left palm and vice versa; rinse hands with water; Thoroughly dry hands with a disposable towel. Utilize a cloth to turn off the faucet. Each of the 11 steps was scored as follows: 0 (step not conducted), 1 (incorrect movement), 2 (correct movement executed too rapidly), or 3 (step performed correctly with appropriate thoroughness). Scores ranged from 0 to 33. Categories were defined as Poor (0-11), Good (12-22), and Very Good (23-33), these cut-offs were defined by dividing the total possible score into three equal bands (low, medium, high) to distinguish children performing fewer than one-third of steps adequately, those demonstrating partial but incomplete technique, and those approaching full compliance with the WHO hand-hygiene procedure.

The game used is ICANDO, a free Indonesian mobile application tailored for preschoolers and built around the national early childhood curriculum. Released during the pandemic, it provided culturally appropriate games in Bahasa Indonesia. The games featured local characters and everyday situations familiar to urban families. The ICANDO mobile app features a meticulously crafted learning path that guides children in acquiring various educational concepts, including numeracy, reading, STEM, positive conduct, and art (Nitae et al., 2025; Wan et al., 2021).

Data collection procedure

To recruit potential participants for the study, the lead investigator contacted eligible participants, explained the study, and obtained informed consent. A demographic questionnaire completed by parents provided baseline data. Following this, the lead investigator observed children's hand hygiene behaviours during a series of hand hygiene observations. Children were then asked to play the ICANDO mobile game application for 10–15 minutes at the discretion of their parents on a schedule that fit into their family's routine. The hand hygiene module was guided by the WHO's 11 Steps to Hand Hygiene via interactive animations in the game. Children received immediate feedback – unlocked badges and chapters in the story – about how various characters remained healthy due to healthy hand hygiene behaviours; thus, using game play creates opportunities for both enjoyment and application of newly acquired knowledge & skills.

In addition to providing supervision for their children, parents actively participated in their children's learning by receiving daily WhatsApp prompts: "Please play the games together today and try to practice the real version after the game." The daily prompts reflect the supporting role of parents in teaching their children through conversation and being role models, thus making screen time into shared family experiences. Respondents were observed for one week and played educational games according to an established schedule for a period of 10-15 minutes per day. On Day 7, respondents (children) were re-evaluated for their hand washing behaviours.

Statistical analysis

Participant characteristics were examined using descriptive or univariate analyses. Because one of the datasets does not follow a normal distribution, the Wilcoxon non-parametric statistical test will be used to compare values before and after the health education program. The data were analyzed using SPSS Version 26.

Ethical consideration

The study was approved by the Health Research Ethics Committee at UPNVJ (No. 497/XII/2021/KEPK).

RESULTS AND DISCUSSION

The results of the Wilcoxon signed-rank test are presented in Table 2.

Table 2. Wilcoxon Signed-Rank Test Results (n = 50)

Measure	Median (Mdn)	IQR	Z	p	r
Pretest	3.0	3.75			
Posttest	15.0	8.75			
Test statistic			-6.034	< .001	.60

Note. $r = |Z|/\sqrt{N}$. Large effect size ($r > .50$).

The Wilcoxon signed-rank test was used to analyze hand hygiene scores due to an asymmetric distribution of the observed differences (Shapiro-Wilk W = .97, p = 0.03). A statistically significant increase in score was found when comparing the pre-test median hand hygiene score (3.00) to the post-test median hand hygiene score (15.00). Z = -6.034; p < .001; r = .60 (large effect). All non-zero difference scores exhibited positive ranks (48 pairs; mean rank = 24.50, sum of ranks = 1176.00), with no negative ranks and 2 tied pairs, which were excluded from the ranking procedure. This suggests a significant improvement in children's hand hygiene scores following their participation in the game-based learning program. Because differences were defined as posttest minus pretest scores, the significant Wilcoxon signed-rank result indicates that hand hygiene scores were higher at posttest than at pretest, supporting the idea that the digital game improved children's handwashing performance.

These findings indicate that hand hygiene scores were higher at posttest than at pretest, supporting the effectiveness of the digital game-based intervention. Handwashing with soap and water was emphasized nationally as a key behavior to prevent COVID-19 and diarrheal diseases (Alzyood et al., 2020). Children, as a major target for behavior-change education, received health and life skills activities through the game to reinforce this message. Key reminders to wash hands at certain times (e.g., before eating, after using the toilet) were embedded in story-based content for young children (Herlinawati et al., 2024). Another engaging health education game utilizing the ICANDO platform is the brushing teeth game. This game is specifically designed to assist children in enhancing their oral hygiene practices and leading healthier lives. A study conducted on preschoolers revealed that their brushing habits significantly improved both before and after utilizing the ICANDO mobile application. This suggests that the application effectively contributed to the development of more effective brushing routines among the participants (Agil et al., 2023). The findings indicated that the game-based oral hygiene education program demonstrated significant short-term retention, underscoring its effectiveness in improving children's brushing habits.

It is well established that gamification of learning encourages the establishment of positive habits by providing immediate feedback (Sailer et al., 2017). The results support this observation, showing that children were very focused and eager to wash their hands during the interactive online game. Our parent-led approach outperformed European institutional studies due to Graichen et al., (2024). contextualized practice, cultural relevance for Indonesian families, and low baseline scores that amplified effect sizes. Design variations elucidate our greater impact: previous research focused on institutional routines, such as fixed sinks and group schedules, whereas ICANDO's mobile, parent-led approach facilitated contextualized practice in genuine home settings, potentially fostering the transfer of skills into everyday behaviors. Additionally, there are distinct cultural differences that separate results from studies done in high-income Europe and the fact that they assume established infrastructure, such as access to soap and literacy, while families in Indonesia experience variable water quality and competing pressures, thus enhancing the overall effectiveness of a home-based intervention in low-and-middle-income nations. The high level of participation by parents with lower to mid-income status in the sample provides evidence for the use of an online learning approach. The data indicate mobile hygiene education may be a feasible alternative within Indonesian early childhood programs, particularly in areas of resource shortage or variable hygiene practices. The low starting scores (Mdn=3.0/33) further magnified our standardized effect size compared to studies that had higher starting points than this study. These findings indicate that online tools directed to families may have particular utility in settings where there are limited resources. More research conducted across various cultures should also be undertaken.

Using the hand washing game allowed for assessing how effective game-based learning was in teaching children proper hand washing practices. Countries around the world, including Indonesia, have developed educational programs about the importance of health in relation to key times when people should wash their hands; to provide information about the proper way to wash their hands and the diseases that may result from improper hand washing. The game and other educational/activity-type games have used vibrant characters and simple, enjoyable tasks to provide participants with information. Those who played this game were not only gaining knowledge, but through making hand washing fun and easy to do, were helping to develop a habit of washing their hands. Hand washing should be seen as a part of daily routines for young children, both at home and in school. To further illustrate the design and features of the game-based learning platform used in this study, Figure 1 presents the main interface and hand hygiene learning components of the ICANDO application.

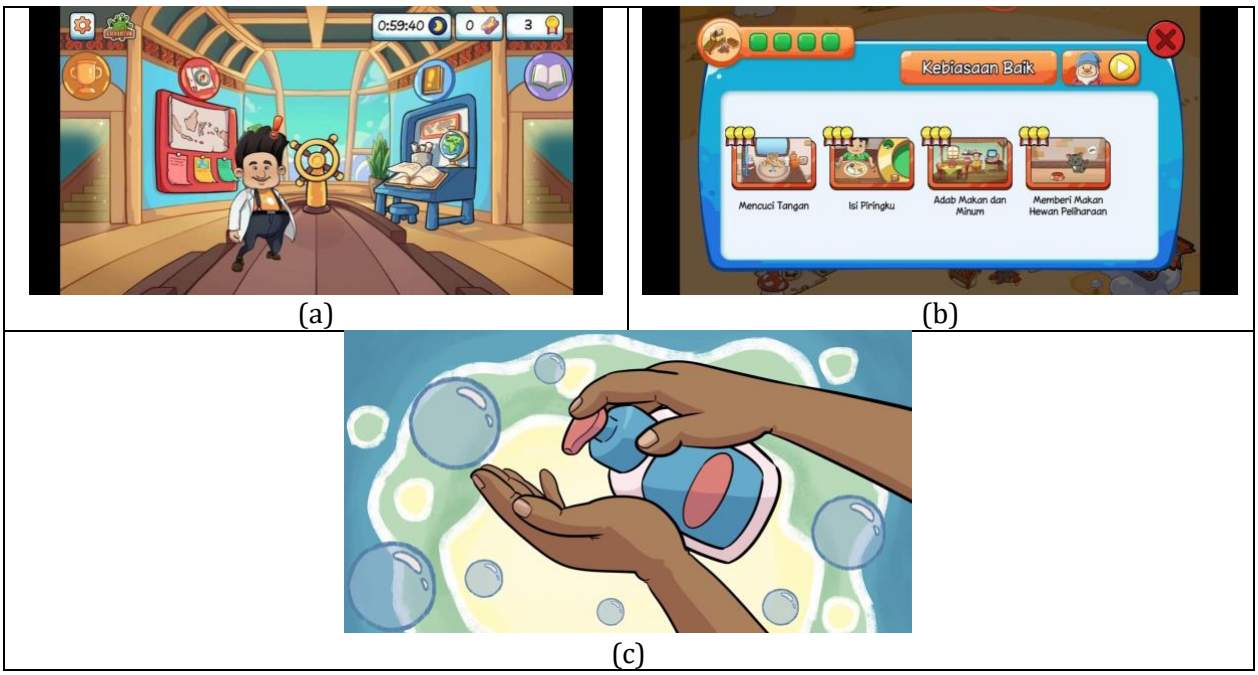

Figure 1. Game Interface and Hand Hygiene Learning Features (a) Dashboard of the Game, (b) Hand Hygiene as One of the Good Habit Options for Children, (c) Using Soap to Wash Hands

Figure 1 presents the main features of the ICANDO game interface. Panel (a) presents the main dashboard, which organizes learning activities, including the "good habits" module where the hand hygiene game is located. Panel (b) shows the available good habit options that children can complete to earn badges. Panel (c) depicts the detailed steps of hand hygiene, including the use of soap during handwashing.

The ICANDO game's constructivist design enabled active learning through story-based tasks and immediate feedback. The zone of proximal development was implemented using multimodal scaffolding, which facilitated the move from assisted practice to independent WHO technique execution. Self-determination theory describes the motivational drivers for engagement. Autonomy (selecting the module), competence (progress badges), and relatedness (parent co-play) maintained the motivation level, which resulted in the acquisition of the skill at a fast rate (Ryan & Deci, 2020; Sailer et al., 2017). These factors collectively contribute to their enhanced handwashing proficiency within a week.

The observed improvement aligns with existing research suggesting that digital health education can foster positive changes in children's hygiene practices (Behnamnia et al., 2023). Game-based platforms effectively disseminate health information through storytelling, visuals, and repetition, all of which are well-suited to children's development. This method is especially beneficial for preschoolers, whose learning often happens through play (Suggate et al., 2021; Zosh et al., 2017). Many studies have explored digital play as a way to enhance young children's learning and development, particularly in areas like learning, creativity, imaginative play, and problem-solving (Chu et al., 2024).

Furthermore, the results support the use of online game-based teaching methods in early childhood health education, especially for teaching basic skills such as proper handwashing. A preceding investigation suggested that online learning materials, encompassing interactive videos, cultivate a sense of self-discipline and accountability among students (Febrini et al., 2024). However, prior research suggests that extended use of digital devices by children between the ages of two and twelve correlates with diminished physical activity and sleep disruptions (Presta et al., 2024). Considering these points, online game-based learning should be viewed as a structured, goal-oriented teaching method, rather than an uncontrolled form of screen-based entertainment (Behnamnia et al., 2023). Therefore, active parental guidance and control are essential to ensure children benefit from the educational value of digital health programs while reducing possible negative effects. This can include setting clear limits on daily screen time, scheduling device use outside of bedtime, and combining digital activities with opportunities for offline play and physical activity.

Future studies, such as RCTs, could provide a promising avenue for the identification of the most efficacious gamification approaches. Research could include the examination of the impact of the time of feedback, the amount of rewards, and the intricacy of narratives on the engagement and learning outcomes of preschoolers. The longitudinal nature of the studies should cover a period of 3-6 months for the evaluation of behavioral changes and the resulting health benefits, such as the reduction of illness incidence. Additionally, a critical evaluation of the amount of screen time for children compared with the WHO-recommended one hour a day is necessary. Through the aforementioned detailed studies, it is possible to determine the cognitive developmental benefits of the games while minimizing the risks associated with the amount of time spent on screens.

LIMITATIONS

The generalization of the results may be limited, especially regarding individuals in the countryside, fathers, caregivers, or families with unstable Internet access. In addition, a detailed examination of potential negative effects, for example, regarding increased screen time, was not performed. Such problems are common when starting research on digital interventions. The results emphasize the importance of conducting more extensive, diverse, and long-term research in future studies. Furthermore, the limited statistical power of the present pilot study was not sufficient to reveal patterns of differential pre-post changes. Therefore, effects could only be detected for large effects. In future studies, a larger sample size is advisable. In addition, a stratified approach or interaction terms in regression analyses could be used to investigate potential moderators. The

Wilcoxon test is a robust test for assessing changes. However, the lack of a control group does not enable the examination of potential external factors. Such factors could be advertisements that ran at the same time as the intervention or reminders from the parents, which could have potentially influenced the results.

CONCLUSION

The results of this particular study indicate that a game-based online learning program, which was conducted through the ICANDO platform, was able to enhance hand hygiene performance in young children. This particular study contributes to the literature by proving the effectiveness of a home-based digital program compared to an institutional program in a resource-limited setting. This implies that a game-based program of health education could be an effective method of enhancing early childhood community programs, especially when used in conjunction with other teaching methods. In light of the growing concern surrounding the potential detrimental effects of too much screen time on young children, it is important to note that such a program could be designed in a way that does not impact the physical activities of young children. This would ensure that young children benefit from learning through games without affecting their well-being.

AUTHOR CONTRIBUTION

YN contributed to the conceptualization, data collection, methodology, writing the original draft, and formal analysis. HM contributed to data validation, review, and editing. TA contributed to visualization and supervision.

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REFERENCES

Abdulrahman, A. O., & Rawf, K. M. H. (2022). Usability methodologies and data selection: Assessing the usability techniques on educational websites. *International Journal of Electronics and Communications Systems*, *2*(2), 49–56. https://doi.org/10.24042/ijecs.v2i2.15045

Agil, H. M., Gowinda, D., Zulviana, & Nurdiantami, Y. (2023). The effectiveness of game-based education "ICANDO" to empowering children to do oral hygiene. *Systems and Empowerment Sciences for Lifespan Development (SYSTED)*, 43–47.

Alzyood, M., Jackson, D., Aveyard, H., & Brooke, J. (2020). COVID-19 reinforces the importance of handwashing. *Journal of Clinical Nursing*, *29*(15–16), 2760–2761. https://doi.org/10.1111/jocn.15313

Ancona, A., Corea, F., Lombardo, C., Gentili, D., Mistretta, & Antonio. (2011). Serious games in child and adolescent health education campaigns: a systematic review. *Ann Ist Super Sanità*, *47*(4), 363–372.

Badan Penelitian dan Pengembangan Kesehatan. (2018). Laporan Riskesdas 2018 Nasional.pdf. In *Lembaga Penerbit Balitbangkes*. https://repository.badankebijakan.kemkes.go.id/id/eprint/3514/1/Laporan Riskesdas 2018 Nasional.pdf

Behnamnia, N., Kamsin, A., Ismail, M. A. B., & Hayati, S. A. (2023). A review of using digital game-based learning for preschoolers. *Journal of Computers in Education*, *10*(4), 603–636. https://doi.org/10.1007/s40692-022-00240-0

Chu, C., Paatsch, L., Kervin, L., & Edwards, S. (2024). Digital play in the early years: A systematic review. *International Journal of Child-Computer Interaction*, *40*, 100652. https://doi.org/10.1016/j.ijcci.2024.100652

Curtis, V., & Cairncross, S. (2003). Effect of washing hands with soap on diarrhoea risk in the community: A systematic review. *Lancet Infectious Diseases*, *3*(5), 275–281.

https://doi.org/10.1016/S1473-3099(03)00606-6
de Wit, S., & Dickinson, A. (2009). Associative theories of goal-directed behaviour: A case for animal–human translational models. *Psychological Research PRPF*, *73*(4), 463–476. https://doi.org/10.1007/s00426-009-0230-6
Faqih, M. V. A., Widiarni, A., Andini, N., Saregar, A., Sharov, S., & Faraj, B. M. (2023). Fisikawaii adventure: An effort to increase students' learning participation through gamification and virtual reality. *Online Learning in Educational Research (OLER), 3*(2), 95–116. https://doi.org/10.58524/oler.v3i2.294
Febrini, D., Aryati, A., Asvio, N., & Syams, W. (2024). Exploring technology integration in islamic character education: Perspectives from early childhood education. *Online Learning In Educational Research (OLER)*, *4*(2), 131–142. https://doi.org/10.58524/oler.v4i2.482
Graichen, J., Stingl, C., Pakarinen, A., Rosio, R., Terho, K., Günther, S. A., Salanterä, S., & Staake, T. (2024). Improving hand hygiene of young children with a digital intervention: A cluster-randomised controlled field trial. *Scientific Reports*, *14*(1), 1–10. https://doi.org/10.1038/s41598-024-56233-9
Haryandi, S., Misbah, M., Arlinda, R., Harto, M., Muhammad, N., Qamariah, Q. (2025). Game-based learning in science education: Bibliometric analysis. *Online Learning in Educational Research (OLER)*, *5*(1), 113–128. https://doi.org/10.58524/oler.v5i1.626
Herlinawati, H., Marwa, M., Ismail, N., Junaidi, Liza, L. O., & Situmorang, D. D. B. (2024). The integration of 21st century skills in the curriculum of education. *Heliyon*, *10*(15), e35148. https://doi.org/10.1016/j.heliyon.2024.e35148
Hidayati, N., & Rudiyanto. (2021). Distance learning in early childhood education during Pandemic Covid-19. *Proceedings of the 5th International Conference on Early Childhood Education (ICECE 2020)*, *538*(Icece 2020), 207–211. https://doi.org/10.2991/assehr.k.210322.045
Hirai, M., Graham, J. P., Mattson, K. D., Kelsey, A., Mukherji, S., & Cronin, A. A. (2016). Exploring determinants of handwashing with soap in Indonesia: A quantitative analysis. *International Journal of Environmental Research and Public Health*, *13*(9), 868. https://doi.org/10.3390/ijerph13090868
Ismail, N. M., & Sabrina. (2023). Virtual learning and memory dissonance. *Jurnal Ilmiah Peuradeun*, *11*(3). https://doi.org/10.26811/peuradeun.v11i3.904
Joseph, V. V. (2022). The impact of public health interventions in a developing nation: an overview. *South Sudan Medical Journal*, *15*(4 SE-Research Article), 147–151. https://doi.org/10.4314/ssmj.v15i4.6
Khan, K. M., Chakraborty, R., Brown, S., Sultana, R., Colon, A., Toor, D., Upreti, P., & Sen, B. (2021). Association between handwashing behavior and infectious diseases among low-income community children in urban New Delhi, India: A cross-sectional study. *International Journal of Environmental Research and Public Health*, *18*(23), 12535. https://doi.org/10.3390/ijerph182312535
Lagu, A. M. H. R., Thaha, R. M., Syafar, M., Hadju, V., & Kurniati, Y. (2022). Using games to promote healthy behavior in children: A narrative review. *Open Access Macedonian Journal of Medical Sciences*, *10*(E), 1904–1910. https://doi.org/10.3889/oamjms.2022.8851
Nitae, K., Nuangchalerm, P., & Safkolam, R. (2025). Bringing science to life: STEM-based instructional strategies for primary students in Thailand. *Online Learning In Educational Research (OLER)*, *5*, 73–80. https://doi.org/10.58524/oler.v5i1.570
Plotka, R., & Guirguis, R. (2023). Distance learning in early childhood during the COVID-19 crisis: Family and educators' experiences. *Early Childhood Education Journal*, *51*(8), 1359–1370. https://doi.org/10.1007/s10643-022-01384-5
Presta, V., Guarnieri, A., Laurenti, F., Mazzei, S., Arcari, M. L., Mirandola, P., Vitale, M., Chia, M. Y., Condello, G., & Gobbi, G. (2024). The impact of digital devices on children's health: A systematic literature review. In *Journal of Functional Morphology and Kinesiology* (Vol. 9, Issue 4, p. 236). https://doi.org/10.3390/jfmk9040236
Ryan, R. ., & Deci, E. . (2020). Self-determination theory. *American Psychologist*, *55*(1), 296–312. https://doi.org/10.4324/9780429052675-23
Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction.

Computers in Human Behavior, *69*, 371–380. https://doi.org/10.1016/j.chb.2016.12.033

Sari, E. F. N., Siregar, N. M., Nugroho, S., Riza, L. S., Ali, M., & Asri, N. (2025). Game-based training model: Does it improve fundamental badminton young athletes' skills? *Journal of Coaching and Sports Science*, *4*(2), 188–198. https://doi.org/10.58524/jcss.v4i2.905

Sari, I. M., Ghinatri, N., Saepuzaman, D., & Amsor, A. (2025). Gamification in learning Newton's laws: Enhancing students' problem-solving skills. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *14*(1), 21–31. https://doi.org/10.24042/jipfalbiruni.v14i1.24829

Shaluhiyah, Z., Qatrannada, S. A., Kusumawati, A., & Miah, M. S. (2025). The effect of digital health intervention in promoting healthy behavior: A systematic scoping review on strategies to prevent non-communicable diseases. *Dialogues in Health*, *7*, 100258. https://doi.org/10.1016/j.dialog.2025.100258

Suggate, S. P., Lenhart, J., Vaahtoranta, E., & Lenhard, W. (2021). Interactive elaborative storytelling fosters vocabulary in pre-schoolers compared to repeated-reading and phonemic awareness interventions. *Cognitive Development*, *57*, 100996. https://doi.org/10.1016/j.cogdev.2020.100996

Tan, C. Y., Jang, S. T., Lam, S. M., An, A. Q., & Lo, U. K. V. (2025). Teaching and learning challenges due to the COVID-19 pandemic: A systematic review. *Educational Research Review*, *47*, 100667. https://doi.org/10.1016/j.edurev.2025.100667

Tidwell, J. B., Gopalakrishnan, A., Unni, A., Sheth, E., Daryanani, A., Singh, S., & Sidibe, M. (2020). Impact of a teacher-led school handwashing program on children's handwashing with soap at school and home in Bihar, India. *PLoS ONE*, *15*(2), 1–8. https://doi.org/10.1371/journal.pone.0229655

Wan, Z. H., Jiang, Y., & Zhan, Y. (2021). STEM education in early childhood: A review of empirical studies. *Early Education and Development*, *32*(7), 940–962. https://doi.org/10.1080/10409289.2020.1814986

Wang, L., Zhang, S., & Rozelle, S. (2024). Do the pathways of child development before age three matter for development at primary school? Evidence from rural China. *Humanities and Social Sciences Communications*, *11*(1), 1578. https://doi.org/10.1057/s41599-024-04104-z

WHO. (2009). *WHO guidelines on hand hygiene in health care*.

WHO. (2017). *Diarrhoeal disease*.

Younie, S., Mitchell, C., Bisson, M. J., Crosby, S., Kukona, A., & Laird, K. (2020). Improving young children's handwashing behaviour and understanding of germs: The impact of A Germ's Journey educational resources in schools and public spaces. *PLoS ONE*, *15*(11 November), 1–19. https://doi.org/10.1371/journal.pone.0242134

Yusaini, Y., Muslim, B., Rusli, R., Darmawati, D., & Hasyim, S. (2024). Covid-19'S effect on lecturer performance and management functions in educational implementation. *Jurnal Ilmiah Peuradeun*, *12*(2), 613–638. https://doi.org/10.26811/peuradeun.v12i2.1185

Zosh, J. M., Hopkins, E. J., Jensen, H., Liu, C., Neale, D., Hirsh-Pasek, K., Solis, S. L., & Whitebread, D. (2017). *Learning through play: A review of the evidence* (Issue November).