

# Bridging Local Culture and Science Education: Interactive Engklek Game as a Tool for Enhancing Environmental Science Communication

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## ABSTRACT

**Objective:** Science communication skills are an essential competency for the 21st century, yet their teaching remains ineffective. Furthermore, local wisdom, such as the traditional game Engklek, has been largely eroded by technological developments and has not been optimized as a learning resource. This study aims to improve students' science communication skills on environmental pollution through interactive digital Engklek media based on local culture. **Method:** The study used a quantitative method with a quasi-experimental pretest-posttest control group design. The sample consisted of 64 seventh-grade students at State Junior High School 53 Surabaya, divided into an experimental class (learning with digital Engklek media) and a control class (conventional learning). The research instruments included a written science communication skills test and an oral communication skills observation sheet. Data were analyzed using the N-Gain test and the independent sample t-test. **Results:** The results of the study showed a significant increase in science communication skills in the experimental class (N-Gain=0.72; high category) compared to the control class (N-Gain=0.49; medium category). The independent t-test produced a significance value of 0.001 (<0.05), proving a significant difference between the two classes. Student responses to the learning media were also very positive. **Novelty:** The novelty of this research lies in the digitization of the traditional Engklek game integrated with an ethnoscience approach, where each game box is designed as a stage in a scientific investigation of environmental pollution. This medium innovatively bridges local wisdom with modern pedagogy to build science communication skills in a contextual and enjoyable way.

## INTRODUCTION

The development of digital technology in this era is growing rapidly so that it brings convenience in human life, including in terms of communication (Entschew, 2021; Govindaraju, 2023). But behind these conveniences, negative phenomena such as *Phubbing*, namely the habit of ignoring people around them because they are too focused on gadgets (Abeele, 2020; Chmielik et al., 2025). This habit will have an impact on the declining quality of social interaction and face-to-face communication, especially among students who grow up in a digital environment (Dibajnia et al., 2025). In addition, globalization and the rapid flow of modernization have resulted in the preservation of local wisdom owned by the Indonesian nation. Traditional games are a form of local wisdom, which not only functions as entertainment but also as a learning medium. Many traditional games that are full of philosophical values and science concepts have been eliminated by the abundance of digital games.

One of the traditional Indonesian games with pedagogical potential is Engklek (Mufidah et al., 2025; Sari et al., 2025; Sukoyo et al., 2021). The integration of local wisdom through an ethnoscience approach is an integral part of community culture and life (Hasibuan et al., 2022; Kristanto & Wibowo, 2023). Culturally-based learning related to natural phenomena in everyday life as ethnoscience. Through ethnoscience learning, students can learn joyfully and master scientific concepts more easily (Hariyono et al.,

2023; Kurniawan & Basuki, 2024). This approach aligns with the framework of culturally responsive pedagogy, which emphasizes the importance of linking academic material to students' cultural knowledge and experiences to enhance their engagement and understanding.

Communication skills are an important skill dimension for students, especially in facing the 21st century (Afikah et al., 2025; Carlgren, 2013). In this skill, students are required to understand, manage, and create effective communication in various forms and content in writing, oral and multimedia. Science communication skills are skills used in investigation activities within the scope of learning outcomes of process skills elements (Burns et al., 2003; Payton-Stewart et al., 2023). Science communication skills are divided into two, namely written and oral science communication skills (Greene, 2016; Kumar & Ranjan, 2025; Rodero, 2025). Activities included in students' written science communication skills are writing practicum reports where the report includes formulating problems, experimental variables, making plans, making data analysis and conclusions. Meanwhile, oral science communication skills include explaining scientific concepts or phenomena clearly and concisely, arguing scientifically based on empirical evidence, and presenting the results of experiments or research orally (Anthony & Moore, 2023).

Based on the results of the pre-research in the form of interviews and the results of questionnaires given to students at State Junior High School 53 Surabaya, it is known that communication skills are still not effective. The communication conveyed is effective if the purpose and purpose conveyed to the communicator can be understood and understood by the communicator. This is coupled with the results of the education report card of State Junior High School 53 Surabaya, there are several indicators that are priority recommendations to be immediately improved, one of which is the indicator of character achievement, good score of 58.5, the root of the problem in the quality of learning, the sub-learning method of the advice given on the education report card is interactive learning practices that are in accordance with learning objectives and student characteristics can support the improvement of the quality of learning that can develop holistic student character including knowledge, affectiveness, abilities and embodiment in behavior (Bulkani et al., 2025; Ma et al., 2019; Syarif & Ghani, 2017).

Although various studies have demonstrated the potential of game-based learning media and ethnoscience approaches in improving the quality of learning, significant research gaps remain. First, most research on traditional games in education focuses on cultural preservation or character development (Abdull Rahman et al., 2025; Syamsurrijal, 2020), few have quantitatively tested their effectiveness on specific 21st-century skills such as science communication. Second, the digitalization of traditional games as a science learning medium has been rarely explored, even though this approach has the potential to bridge the gap between endangered local wisdom and the needs of technology-based learning. Third, previous studies on science communication tend to use conventional approaches and have not integrated local cultural elements as meaningful learning contexts.

To fill this gap, this study proposes interactive digital Engklek media as a learning innovation that integrates local wisdom (Engklek game) with an ethnoscience approach to improve science communication skills on environmental pollution. Specifically, this study aims to: (1) test the effectiveness of interactive digital Engklek media in improving

students' science communication skills compared to conventional learning; (2) describe students' responses to the use of local culture-based media in science learning; and (3) analyze the mechanisms by which digitalized traditional games can bridge local culture with modern science pedagogy. This research is expected to provide theoretical contributions to the development of digital game-based ethnoscience learning models, as well as practical contributions for teachers in designing science learning that is contextual, innovative, and remains grounded in cultural roots.

## RESEARCH METHOD

### Research Design

This study employed a quantitative research method with a quasi-experimental method. The choice of a quasi-experimental design was based on practical and ethical considerations in the school environment, where researchers could not perform true randomization on the research subjects because the classes were naturally formed (intact groups) by the school. Therefore, researchers used pre-existing groups without randomizing individuals, while still controlling for threats to internal validity through equivalent group selection procedures and initial measurements (pre-test).

The specific design used was a pretest-posttest control group design. This design was chosen because it allowed researchers to compare improvements in science communication skills between the treatment group (experimental class) and the untreated group (control class), by measuring initial abilities (pre-test) and final abilities (post-test) in both groups. Table 1 shows the research design used.

**Table 1.** Pretest-posttest control group design

Groups	Pretest	Treatment	Posttest
Experiments	O1	X (Engklek Media)	O2
Controls	O1	- (Reguler learning)	O2

### Experimental Structure and Procedure

The experiment was conducted in three main stages during the period January-February 2026 at State Junior High School 53 Surabaya.

#### *Stage 1: Preparation*

At this stage, researchers developed and validated research instruments (written science communication skills tests, oral skills observation sheets) and developed interactive digital Engklek learning media. The media and instruments were validated by three experts: two science education experts and one learning media expert.

#### *Stage 2: Implementation*

The experimental procedure lasted four weeks (eight meetings) with the following details: 1.) Meeting 1: A pretest of written science communication skills was administered to both classes (experimental and control) for 60 minutes; 2.) Meetings 2-7: Implementation of the learning process. The experimental class (VII B) participated in learning using interactive digital Engklek media for six meetings (2 x 40 minutes). The control class (VII A) participated in conventional learning with lectures and group

discussions on the same topic (environmental pollution) for an equivalent duration; 3.) Meeting 8: A posttest of written science communication skills was administered to both classes, as well as the completion of a student response questionnaire in the experimental class.

Throughout the learning process, the researcher was assisted by two observers who observed the students' oral science communication skills using a provided observation sheet. The observers were student interns who had been previously trained to ensure consistency of assessment.

### ***Stage 3: Data Analysis***

The collected data is analyzed using predetermined statistical techniques to answer the research questions.

### **Population and Sample**

The population of this study was all seventh-grade students of State Junior High School 53 Surabaya in the 2025/2026 academic year. The sampling technique used purposive sampling, considering that both classes had relatively similar characteristics based on information from subject teachers (the average score of previous daily tests was not significantly different). From the existing population, class VII A was selected as the control class (conventional learning) and class VII B as the experimental class (learning with digital Engklek media). Each class consisted of 32 students, so the total research subjects were 64 students.

### **Data Analysis Techniques**

The instruments used in this study were written and oral science communication skills instruments and observation sheets of science communication skills during the learning process. There are several data collection techniques used in this study, such as test and observation techniques. The data analysis technique used in this study involves descriptive statistical analysis to describe oral science communication skills, analysis prerequisite test, effectiveness test using N-Gain Score and N-gain score difference test. The value of oral science communication skills is known from the results of calculations using the following equation.

$$Score = \frac{Obtained\ Score}{Ideal\ Score} \times 100$$

Students' oral science communication skills data are in the form of qualitative data that is converted into scores. The data was obtained from the observation of oral science communication skills. The purpose of this study is to strengthen students' science communication skills known through the calculation of n-gain scores using the following equations.

$$gain\ score = \frac{posttest\ score - pretest\ score}{ideal\ score - pretest\ score}$$

The n-gain score was then interpreted according to the following criteria referring to Hake (1999).

**Table 1.** Normalized gain criteria

Gain score range (g)	Gain score criteria
$g \geq 0.70$	Height
$0.30 < g \leq 0.70$	Medium
$g < 0.30$	Low

The n-gain score data was then tested with inferential statistics such as normality tests and homogeneity tests. The normality test is used to test whether a variable has normal data or not and the homogeneity test is carried out to find out whether the class used for the research is a homogeneous class (equal or not). The difference in science communication scores between the two groups was analyzed using an independent sample t-test assuming homogeneous variance after meeting the prerequisites of normality (Shapiro-Wilk,  $p > 0.05$ ) and homogeneity (Levene's test,  $p > 0.05$ ).

## RESULTS AND DISCUSSION

### Results

The results of this study are based on data obtained from research which aims to test the effectiveness of interactive digital Engklek learning media based on local culture in improving science communication skills on environmental pollution materials. Quantitative and qualitative data analysis produced key data: (1) the effectiveness of media on improving science communication (2) students' response to the integration of traditional Engklek-digital games in science learning (3) the mechanism of bridging local culture in science learning.

### *The Effectiveness of Interactive Digital Engklek Media in Improving Science Communication Skills*

The effectiveness of Engklek Digital Interactive learning media based on local culture in improving written science communication skills. The written science communication skills test instrument uses 6 questions containing scientific investigations of environmental pollution. The following is the effectiveness of Engklek Digital Interactive learning media in improving written science communication skills.

**Table 2.** Pretest and Posttest Descriptive Statistics

Classes	N	Pretest (M±SD)	Posttest(M±SD)	N-Gain	Categories
Experiments	32	41.09±10.1	82±8.8	0.72±0.95	Height
Conventional	32	43.38±8.62	70.88±10.1	0.49±0.138	Medium

Table 1 shows the results of descriptive statistical analysis showing that the average *pre-test* and *post-test* scores of students' writing science communication skills. Based on this data, it can be seen that students have an average *pre-test* score in the experimental class of 41.09 with a standard deviation of 10.1 and a *post-test* score of 82 with a standard deviation of 8.8. Meanwhile, the n-gain score in the experimental class was 0.72, which showed a significant improvement in students' abilities after participating in learning. The rate of increase is categorized as high based on the criteria used.

In the conventional class (Ordinary Learning), the results showed that students had an average pre-test score of 43.38 with a standard deviation of 8.62 and a post-test score

of 70.88 with a standard deviation of 10.1. Meanwhile, the n-gain score was 0.49, which indicates an increase in learning outcomes but shows a moderate category.

Based on the descriptive analysis of the N-Gain calculation, it was concluded that learning in experimental classes provided a more significant increase in learning outcomes than conventional classes. Thus, this data reflects the success of the learning carried out, where most students managed to achieve high n-gain. These results show that the application of Engklek learning media is effective in improving students' science communication skills.

Based on the results of the calculation that has been obtained, the n-gain score is 0.72 with a high category in the experimental class. The n-gain score data in table 3 when tested for normality using *SPSS Statistics software*, the following information will be generated:

**Table 3.** Results of the normality test of the n-gain score data of the experimental class

	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
N_gainscore	0.119	32	0.200*	0.973	32	0.572

\*. This is a lower bound of the true significance

a. Lilliefors Significance Correction

Table 3 shows the normality of the n-gain score data using the Kolmogorov-smirnov statistical test with a significance of 0.200 and the Shapiro-wilk statistical test with a significance of 0.572, so that if reviewed from the results of both the Kolmogorov-smirnov statistical test, and the Shapiro-wilk test, the n-gain score data is normally distributed.

The conventional class n-gain score data in table 3 if tested for normality using *SPSS Statistics software*, the following information will be generated:

**Table 4.** Normality test results of n-gain score data of conventional class

	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
N_gain	0.123	32	0.200*	0.932	32	0.45

\*. This is a lower bound of the true significance

a. Lilliefors Significance Correction

Table 4 shows the normality of the n-gain score data using the Kolmogorov-Smirnov test, showing a significance result of 0.200 and the Shapiro-wilk test of 0.045, so that if reviewed from the Kolmogorov-Smirnov test, the n-gain score data is normally distributed. When the n-gain score data in Table 4 is tested for homogeneity using *SPPS Statistic*, the following information will be generated:

**Table 5.** Data homogeneity of written science communication skills

			Levene Statistic	df1	df2	Sig.
Written Science Communication Skills	Based on	Mean	2.122	1	62	0.150
	Based on	Median	1.731	1	62	0.193
	Based on	Median and with adjusted of	1.731	1	58.396	0.193
	Based on	trimmed mean	2.004	1	62	0.162

Table 5 shows the data homogeneity of the n-gain score data of the value of written science communication skills using the Levene statistical test with good significance showing a value greater than 0.05 so that it can be said that the sample data comes from a population with the same variant.

If the normality and homogeneity tests are met, then an independent sample t-test will be carried out. The n-gain score data in Table 1 was carried out by an independent t-test sample to determine the difference in n-gain results between the experimental class and the conventional class, the following data was produced:

**Table 6.** Independent Sample T-Test Test Results N-Gain Score

		Independent Samples Test									
Levene's test for Equality of Variances		t-test for Equality of Means									
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
										Lower	Upper
Post-tets	Equal variances assumed	2.122	0.150	5.448	62	<.001	12.250	2.248	7.755	16.745	
Post-tets	Equal variances assumed			5.448	57.983	<.001	12.250	2.248	7.749	16.751	

The results of the independent t-test sample showed a statistically significant difference between the experimental class and the conventional class, this is evidenced in Table 6 with a significant value of  $0.001 < 0.05$ . There was a significant difference in the mean of the two groups if the p value  $< 0.05$ . Thus, this data reflects that the effectiveness of interactive Digital Engklek learning media in improving students' science communication skills.

## Discussion

The research findings indicate a significant difference in science communication skills improvement between students learning with interactive digital Engklek media in the experimental class and students learning with conventional learning in the control class. Statistical analysis revealed that the N-Gain value of the experimental class was in the high category (0.72), while the control class only achieved a moderate score (0.49), with a statistically significant difference ( $0.001 < 0.05$ ). This finding indicates that the interactive digital Engklek media not only "assist" learning but also substantially accelerate the improvement of students' science communication skills. This higher effectiveness in the experimental class is interesting to analyze further from a theoretical perspective and the pedagogical mechanisms at work.

The effectiveness of digital Engklek media in improving science communication skills can be explained by several specific mechanisms designed into the media. First, each square in the digital Engklek game is designed to represent the stages of the scientific method. As students jump and land on specific boxes, they are presented with varying cognitive challenges: Box 1 presents a pollution phenomenon to be observed (practicing sensitivity), Box 2 asks students to formulate a problem based on observations (practicing identification), Box 3 provides data to be analyzed (practicing interpretation), and Box 4 asks students to draw conclusions and communicate them (practicing articulation). This step-by-step structure aligns with the inquiry learning cycle, which requires students to actively construct understanding through direct experience. Thus, science communication skills are not taught separately but are integrated into playful activities that require students to naturally practice scientific communication (Ferraz-Caetano & Dias, 2021).

Second, digitalization allows for visual and interactive presentations of environmental pollution phenomena. Students not only read text about water pollution but can also witness simulations of water color changes due to waste, or view animations of pollution's impact on ecosystems. These visualizations help students build richer mental schemas about abstract concepts, which in turn makes it easier for them to explain these concepts verbally and in writing. Research by Mayer, (2014, 2024) on the cognitive theory of multimedia learning confirms that the right combination of words and images can increase students' capacity to process information and communicate it back.

The success of this media is also inseparable from its underlying theoretical foundations, namely the ethnoscience approach and game-based learning. Within an ethnoscience framework, scientific knowledge is not presented as something foreign and separate from students' lives, but rather closely linked to the culture they are familiar with. The Engklek game, as part of local wisdom, creates a familiar and meaningful context for students (Kamid et al., 2021; Kristanto & Wibowo, 2023; Romanvican & Istiyono, 2020). Integrating traditional knowledge into science learning can increase students' personal relevance and intrinsic motivation (Jufrida et al., 2025; Nguyen et al., 2025). When students play Engklek while learning about environmental pollution, they do not feel like they are "learning" in the formal sense, but rather "playing science" within their own cultural context. This explains the highly positive student response to this media, as reported in the findings.

From a game-based learning perspective, Benachour & Zhao, (2024), Katual et al., (2023), and Nahar & Storey, (2023) explains that games are effective for learning because they involve six key elements: rules, goals, challenges, interactivity, feedback, and stories. The digital Engklek media adopts all six of these elements. The rules of the Engklek game (hopping on one leg) are maintained, the main objective is to complete a scientific investigation in each square, challenges are presented in the form of analytical questions, interactivity occurs when students discuss with their group mates, feedback is provided after students answer questions, and a story about environmental pollution becomes the common thread that ties the entire game together. This combination of elements creates a state of flow where students are fully engaged in the activity, lose track of time, and enjoy the learning process.

These findings align with research by Khoirunnisa, (2022), who developed an integrated STEM-Project Based Learning (LKPD) e-LKPD supported by interactive multimedia and reported an increase in students' communication skills with an N-Gain of 0.86 (high category). However, our research extends these findings by demonstrating that a local culture-based approach (ethnoscience) can be effectively integrated into digital media, something not explored in Khoirunnisa's study. In other words, our research confirms the effectiveness of interactive media as reported by Khoirunnisa, while also adding to the literature with evidence that traditional cultural elements can actually strengthen, rather than diminish, the appeal of digital media.

Manja et al., (2025) study concluded that digital media increases student engagement and supports conceptual understanding. Our findings not only confirm this but also provide a more specific explanation of how this engagement occurs, namely through the structured inquiry mechanism within the game. Similarly, Putra & Mailinda, (2025) study of the game "Science Monopoly" showed that students learning with a game based on the Toulmin Argumentation Pattern were able to present claims and support them with relevant data. Our study corroborates these findings with a different cultural context (Engklek vs. Monopoly) and demonstrates that scientific argumentation patterns can be practiced through various digitalized traditional game formats.

Interestingly, although the control class also showed improvement (N-Gain 0.49), the improvement was significantly lower. This indicates that conventional learning with traditional lecture and discussion methods, while still beneficial, is unable to create optimal learning conditions for practicing science communication. In conventional learning, students tend to passively receive information and have limited opportunities to practice scientific communication (Hadiyanto et al., 2021; Rafiqui et al., 2022). In contrast, the digital Engklek media forces students to actively produce knowledge, rather than simply consume it (Hariyono et al., 2023; Hidayat et al., 2021).

These findings have important implications for science learning practices in schools. First, teachers need not view digital technology and local wisdom as opposing forces. Instead, they can be synergistically combined, as demonstrated in this study. Second, the development of learning media should consider gradual scaffolding, guiding students from simple tasks (observation) to complex ones (communication of results). Third, game elements should not be merely tacked on, but should be integrated with pedagogical objectives, just as each Engklek square represents a stage of the scientific method.

However, it should be noted that the effectiveness of this media still needs to be tested on different science materials and at more varied educational levels. This study was also

limited to short-term measurements, so it is unknown whether improvements in science communication skills are sustained over the long term.

## CONCLUSION

**Fundamental Finding:** This study proves that the local culture-based interactive digital Engklek media is significantly effective in improving students' science communication skills on environmental pollution material. The main findings show a high category increase (N-Gain=0.72) in the experimental class, significantly different from the control class (N-Gain=0.49;  $p=0.001$ ). This effectiveness is achieved because the media design adapts traditional games into scientific investigation stages, allowing students to learn science contextually while maintaining elements of local wisdom. **Implication:** Theoretically, this study strengthens the view that an ethnoscience approach packaged in digital media is able to bridge the gap between local culture and modern pedagogy. Practically, these findings contribute to the development of innovative learning models that not only improve 21st-century skills but also preserve traditional games that are almost extinct. Digital Engklek media can be adopted by teachers as an alternative to contextual and meaningful science learning, especially in materials that require conceptual understanding and scientific investigation skills. **Practical Recommendations for Classroom Implementation:** Based on the research findings, the following are practical recommendations for teachers who want to implement digital Engklek media or similar media in science learning: 1.) Technical and Pedagogical Preparation: Teachers need to ensure the device is ready to use and understand the game flow and the relationship of each box to the stages of the scientific method. Game simulations before learning are highly recommended; 2.) Time and Class Management: Allocate time proportionally (20% introduction, 60% group exploration, 20% presentation and reflection). Divide students into small groups (3-4 people) to encourage discussion and collaboration; 3.) Integration with Inquiry Activities: Integrate media with real-life practical activities. For example, after completing the water pollution data analysis challenge, invite students to test the water quality in the surrounding environment; 4.) Assessment Instrument Development: Prepare a clear assessment rubric to measure science communication skills, including aspects of clarity of explanation, accuracy of scientific terms, completeness of data, and the ability to draw conclusions; 5.) Alignment with the Independent Curriculum: This media is in line with the principles of differentiated learning and strengthening the Pancasila Student Profile, especially the dimensions of mutual cooperation, creativity, and critical reasoning. It can be integrated into the Pancasila Student Profile Strengthening Project (P5) with the theme of Sustainable Lifestyle; 6.) Documentation and Reflection: Invite students to document the game process and investigation results in a journal or simple report, and conduct a reflection session at the end of the lesson. **Limitation:** This study has several limitations. First, the measurement of oral science communication skills has not been analyzed quantitatively and in-depth. Second, the scope of the material is limited to environmental pollution, so the generalizability of the findings requires further study. Third, the relatively short duration of the intervention (January-February 2026) may not be sufficient to measure long-term impacts. Fourth, the technical description of the Engklek digital media has not been validated and published in detail. **Future Research:** Further research is recommended to: 1.) integrate quantitative and qualitative data analysis of oral communication skills; 2.) test the effectiveness of media on different science materials

and broader educational levels; 3.) conduct longitudinal studies to test the retention of science communication skills, and 4.) document and publicly publish the technical development of digital Engklek media so that it can be replicated and studied by other researchers.

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