Picture Science Story Game App: What Effects on Early Childhood Science Process Skills?

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***Abstract*—This study aims to explain the effect of the Picture Science Story Game App (PSSGA), integrated with Minangkabau local wisdom, on the science process skills of early childhood learners. This study employed a quasi-experimental design with a pretest-posttest group design. The sample consisted of 58 early childhood students divided into two groups: the control group and the experimental group. The control group received instruction using picture media, while the experimental group was taught using PSSGA media. The research instrument used was an observation sheet, and data analysis was conducted using the Wilcoxon test and the Mann-Whitney test. The findings revealed that the *p*-value was less than 0.05, indicating that learning with integrated PSSGA media was more effective than learning with picture media. The effect size for the experimental group was 0.855, suggesting a large effect. Thus, the integrated PSSGA media incorporating Minangkabau local wisdom proved to be effective in enhancing early childhood science process skills.**

***Keywords*—early childhood education, game, local wisdom, picture science story, science process skills**

I. Introduction

Early childhood is when children can absorb information and messages very well. Therefore, during this period, children require optimal stimulation to develop well. Early childhood is in the absorbent mind phase, a time of absorbing thoughts. During this phase, children undergo growth and development in various aspects. One area of early childhood knowledge related to cognitive development is the introduction to science. Science process skills involve experiencing an event logically through a series of systematic methods [1]. It is also a skill that consists of the experience of facts presented scientifically through orderly steps, resulting in general knowledge [2].

Introducing science in early childhood education emphasizes developing process skills rather than products. Science process skills include knowing, observing, understanding, conducting experiments, and solving problems in the surrounding environment. Through this process, children can develop logical and organized thinking. Additionally, these skills provide a foundation for children to understand various phenomena around them with a systematic approach [3]. The science process has five main skill aspects: observing, measuring, comparing, classifying, and communicating [4, 5]. All these skills are designed to help children recognize scientific facts in a structured way [6]. With the right approach, introducing science in early childhood can be a strong foundation for cognitive development and the child's curiosity [3].

The utilization of technology plays a crucial role in supporting the mastery of science process skills in early childhood education. As a learning medium, technology has become an urgent need to help children develop science skills optimally [7]. Technology-based learning media, such as Android application-based educational games, can support enjoyable and interactive learning activities [8, 9]. These educational games are played through gadgets, smartphones, or Android devices and are designed for children's learning [10]. This medium serves as an entertainment and educational tool that can train children's science process skills, such as observing, measuring, comparing, classifying, and communicating [11]. Choosing an appropriate strategy in the learning process greatly influences developing children's scientific processing abilities [12].

However, this condition often does not align with the learning practices in early childhood education. Many children still struggle to develop science process skills, and the learning media used have not fully supported the mastery of these skills [13]. Facts and activities in the daily cultural environment can be essential factors in training science process skills [14, 15]. Integrating local cultural wisdom into learning, such as Minangkabau culture, is a relevant approach to introducing science in a context close to children's lives [16]. Unfortunately, this integration is still very limited, so the potential of local culture to support science process skills has not been fully utilized. This issue is also supported by previous research, which shows children's low science process skills due to media limitations and the lack of integration of local wisdom.

The results of preliminary research show that science learning in early childhood faces serious issues, ranging from the low science process skills of children, such as observing, measuring, comparing, classifying, and communicating, to the limitations of learning media that have not optimally supported the development of these skills [17]. Monotonous and less engaging media fail to motivate children to understand science concepts relevant to their daily lives. Furthermore, the minimal integration of local wisdom, such as Minangkabau culture, eliminates the potential for contextual learning that can introduce cultural values while also training science skills. The absence of relevant technology-based media further exacerbates the situation, emphasizing the urgency of science learning innovation that combines technology, local wisdom, and the comprehensive development of children's science process skills.

As a solution, an innovation in technology-based learning media, such as Android-based educational games integrated with local wisdom, can be applied as an alternative to support the development of science process skills in early childhood

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education. Android-based educational games are designed to incorporate elements of local wisdom, such as Minangkabau culture, to support science process skills. This media can present illustrated science stories that introduce local cultural values and support the comprehensive learning of science process skills. Therefore, this study aims to explain the effect of the Picture Science Story Game App (PSSGA), integrated with Minangkabau local wisdom, in improving early childhood science process skills.

II. Literature Review

A. Early Childhood Education and Technology

Technology in early childhood education refers to using digital devices and technology-based systems to support early learning. Technology is crucial in enhancing early childhood learning experiences through more interactive and engaging interactions [18]. The utilization of technology in early childhood education must be tailored to the developmental needs of early childhood and ensure that its use continues to support their sensory and motor development [19].

The trend of technology use in early childhood education continues to evolve, particularly with the increasing use of digital devices in family and school environments. The technology may include educational software and smartphone-based applications that support early childhood cognitive, social, and emotional development [18]. Recent studies indicate that smartphone-based learning applications are becoming increasingly popular due to their accessibility and flexibility in use [20]. This technology aims to enhance early childhood engagement in the learning process, reinforce challenging concepts, and provide a more enjoyable learning experience [21].

Before the advancement of digital technology, learning media for early childhood predominantly utilized conventional aids such as picture books, educational cards, and physical manipulative-based games [22, 23]. Although these media have proven effective in supporting child development, several limitations have been identified, such as restricted access to broader learning resources and a lack of interactivity that could enhance early childhood exploration of science and technology concepts [23]. Another drawback is the absence of immediate feedback from conventional media, which makes it challenging for early childhood to understand cause-and-effect relationships directly in learning.

In addressing the limitations of traditional learning, integrating learning by adopting smartphone-based media can serve as an alternative solution. Interactive smartphone-based learning applications can be designed to provide a more engaging learning experience through animations, sound, and interactive simulations [24]. In addition, this application can be tailored to the early childhood developmental level and provides real-time feedback to enhance their understanding. With features such as gamification [25]. Challenge-based learning and game-based exploration, along with smartphone technology, can enhance children's motivation to learn and assist them in developing critical thinking skills from an early age [26]. Technology integration in early childhood education assists the development of science and literacy skills [27]. Learning with technology creates an interactive learning process for young children [28]. Therefore, integrating digital technology is an effective method of guiding child-centered learning [29].

Further innovation in the use of technology for early childhood education involves integrating scientific process skills with the local Minangkabau culture. The rich philosophy of Minangkabau culture teaches that humans can learn from nature and their surroundings. This philosophy can be adopted in the learning process by utilizing smartphones to teach children about nature exploration, observation, and problem-solving, as well as simple physics concepts applied in the daily life of the Minangkabau community. This approach helps children understand science contextually and introduces them to local wisdom, which can strengthen their cultural identity.

By integrating smartphone-based technology, science process skills, and the local Minangkabau culture, innovations in early childhood education can provide a more holistic learning experience. This approach allows children to understand scientific concepts and apply them in their daily lives within the context of their own culture. Therefore, testing the effects of integrating technology, science process skills, and the local Minangkabau culture requires significant research to determine its impact on improving student learning outcomes.

B. Picture Science Story

Research in early childhood education has highlighted the importance of engaging and interactive media in science learning. One increasingly popular approach is picture science story, a teaching method that combines picture-based storytelling with scientific concepts. This approach allows children to grasp scientific concepts more concretely and comprehensibly through engaging storylines [30]. With strong visualizations, children can more easily connect abstract concepts to their real-life experiences [31].

The picture science story method serves as a tool for delivering information and as a medium to enhance early childhood science process skills. Children are encouraged to observe, classify, measure, and make predictions based on the stories presented. This method enhances memory retention and comprehension by integrating narrative elements as the acquired information becomes more meaningful [32, 33]. Additionally, the story-based approach supports the development of critical thinking and problem-solving skills in young learners.

Media in moving images and narratives has a psychological impact that influences early childhood attention, promoting better conceptual understanding and facilitating their cognitive responses [34]. Presenting images and animations in learning influences working memory and enhances early childhood cognitive flexibility in learning [35]. The integration of innovative learning serves as one of the solutions to strengthen students' mental resilience while also supporting the development of their imagination and creativity in learning [36, 37]. Audio in stories can influence students' emotions, positively impacting their interest in learning [38]. The images presented in a story help to depict emotions, creating a more engaging learning atmosphere for students [39].

One of the key advantages of picture science story is its ability to capture early childhood attention through rich visual elements. Research indicates early children comprehend concepts more quickly with engaging illustrations [40]. Visual representations in science stories help children build a stronger conceptual understanding [41], particularly for abstract topics such as changes in matter, life cycles of living organisms, or force and motion concepts [42, 43]. This approach transforms children from passive listeners into active explorers of scientific concepts embedded in stories.

However, despite its numerous benefits, certain challenges exist in its implementation. One of the primary limitations is the lack of hands-on experimentation. While picture science stories aid in understanding scientific theories, without direct practice, children may struggle to apply learned concepts in real-life situations [44]. Therefore, this approach should be complemented by hands-on exploratory activities or simple experiments that children can perform independently.

With technological advancements, picture science stories can be adapted into various digital media, such as educational game-based applications. Using apps that integrate picture-based science stories with interactive elements can offer children a more immersive and enjoyable learning experience. This technological integration also allows for personalized learning, adapting to each child's developmental level, thus enabling more effective learning. Therefore, further research is needed to examine the effectiveness of digital media applications in the picture science story approach for enhancing early childhood science process skills.

C. Science Process Skills

Research on science process skills in early childhood education has been extensively conducted to examine the development of essential scientific skills that form the foundation of children's knowledge and abilities. In general, previous studies indicate that the development of science process skills positively impacts early childhood education [45]. Skills such as observation, measurement, classification, and experimentation significantly help children understand fundamental scientific concepts they encounter in their daily lives [46, 47]. Various teaching approaches have been implemented to enhance these skills, one of which involves using innovative and engaging media.

However, despite significant enhancements in children's science process skills through various instructional methods, there are still gaps in the implementation of learning strategies that effectively accommodate young learners' needs. Some studies have revealed that many existing methods fail to fully engage children or do not align with their natural learning preferences, which are highly interactive and play-based. This highlights the importance of developing more suitable learning media tailored to early childhood characteristics, such as educational games that support science learning in a fun and interactive manner. Training science process skills can be enhanced by implementing narrative text-based inquiry learning [48].

Digital learning media is closely related to child psychology, skills, and learning outcomes, particularly in the context of science abilities and the scientific process [49]. Research indicates that this media can make science learning more engaging, enhance early childhood motivation, and assist them in better understanding scientific concepts [50]. For instance, interactive media can encourage children to observe, experiment, and solve problems, which are integral parts of the scientific process. With their interactive features and game-based elements, educational games offer a potential solution to address these limitations. Previous research has shown that game-based learning in early childhood education can enhance cognitive and social skills, particularly in critical thinking and problem-solving [7]. Games can be designed to introduce scientific concepts engaging and easily comprehensibly, allowing children to learn through play. The skills of the science process can enhance students' abilities in learning [51]. The stages of inquiry-based learning in the learning process help train science skills in early childhood [52].

Nevertheless, research gaps remain in exploring the integration of educational games with the development of science process skills in early childhood education. Implementing local cultural wisdom has great potential in teaching science process skills, especially through the Minangkabau local wisdom approach. However, studies examining the integration of local culture into educational game-based learning remain limited.

Further research is needed to explore the effectiveness of various types of educational games that can be applied in early childhood learning environments. Additionally, it is crucial to investigate how these games can be effectively integrated with traditional teaching methods to optimize the development of science process skills in young learners.

III. Materials and Methods

A. Research Design

This study used a quasi-experimental research design to compare group science process skills. The primary goal of this design was to investigate differences in outcomes across multiple groups subjected to varying treatments. Based on pretest and posttest results, this research design was chosen to assess the differences in science process skills. The quasi-experimental approach involved four groups: two control groups and two experimental groups, as outlined in Table 1.

Table 1. Quasi-experimental methods

Group	N	Pretest	Treatment	Posttest
Control	28	X1	Picture	X2
Experimental	30	X1	Learning with PSSGA	X2

X1 = Pretest activity, X2 = Posttest activity.

B. Participants

The population in this study consisted of kindergarten students in Payakumbuh. The research sample comprised 58 early childhood aged 5 to 6, distributed across a control group and an experimental group. The sampling technique used in this study was purposive sampling, a method aimed at selecting the most relevant samples for the study without including the entire population of kindergarten students.

The placement of participants into control or experimental groups was based on specific selection criteria, such as the equivalence of initial characteristics based on pretest scores. The average pretest scores of both groups were not significantly different, 57.8 and 58.2. Furthermore, the results of statistical tests indicate that there was no significant difference between the two groups based on pretest scores. Therefore, the group division was conducted without causing problems or biases in its selection. Consequently, the class with the highest average pretest score was designated the control group, while the class with the lowest average pretest score was designated the experimental group.

C. Implementation

The implementation of this study was conducted over eight sessions for each group, with each session lasting 2 hours. A pretest was administered to each group in the initial stage to measure the early childhood baseline abilities. Following this, learning activities were conducted using different media. Learning was carried out for the control groups using pictures. Meanwhile, in the experimental groups, the PSSGA was used for learning. After six learning sessions, the early childhood abilities were assessed through a posttest. The stages of the learning implementation procedure are presented in Fig. 1.

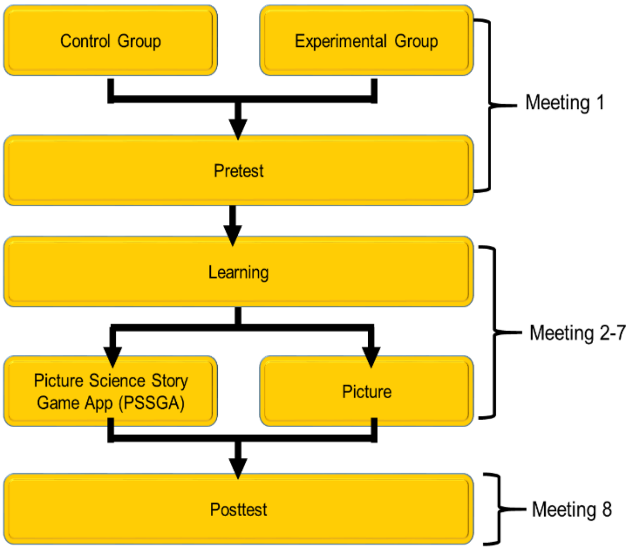

Fig. 1. Research implementation procedures.

Fig. 1 illustrates the stages of the research procedure. During the learning phase, young children participate in activities designed to develop their science process skills, focusing on Minangkabau local wisdom, particularly in the context of traditional food-making processes. The learning implementation involves exploring the process of making traditional Minangkabau foods, such as Minangkabau traditional yogurt, palm sugar, and glutinous rice, all of which reflect the region's rich culinary heritage. Children are guided through various learning stages to enhance their science process skills using different approaches in two research groups. The control group used printed images without narration or procedural explanations. The experimental group used PSSGA media, which allowed children to explore Minangkabau local culture more interactively by visualizing the food-making process systematically. The media used in the experimental group is shown in Fig. 2. After the learning activities, the children's science process skills were observed and assessed through a post-test to evaluate their enhancement.

Fig. 2 and Fig. 3 show the PSSGA media used in the experimental group, which provides several interactive features to help early children practice science process skills. In this application, there is a navigation button to display the procedure steps for making traditional Minangkabau food, presented in the form of a storyboard. Additionally, there is a sound button that narrates the story to the early children, accompanying the procedure flow displayed to the early children. The unique feature of audio narration, which tells the story directly and repeatedly to early children, offers an advantage over the traditional printed images previously used in their learning.

Fig. 2. PSSGA of part 1.

Fig. 3. PSSGA of part 2.

Table 2. Science process skills indicators

Category	Indicator
Observing	a. Using the sense of touch to recognize the tools and materials. b. Using sight and hearing to identify the steps involved. c. Using taste and smell to identify the flavors and aromas.
Measure	a. Identifying the tools used. b. Identifying the materials used. c. Identifying the time required for the process.
Compare	a. Identifying similarities in the objects used. b. Identifying differences in the objects used.
Classify	a. Classifying the tools and materials used. b. Classifying the properties of the objects used. c. Classifying the process steps.
Communicate	a. Recounting the results of the activities conducted. b. Answering questions posed by the teacher.

D. Data Collection

The research instrument utilized an observation sheet to assess early childhood science process skills. These skills were grouped into five main categories: measuring, comparing, classifying, and communicating. Each category was divided into several question indicators for a focused and in-depth assessment. In total, 13 indicators were used to measure early childhood science process skills. These indicators covered various essential aspects of early childhood's ability to understand and apply scientific concepts practically and theoretically. The details of the science literacy skill indicators are presented in Table 2.

E. Data Analysis

The data in this study consists of pretest and posttest scores from the research group. This data was processed using SPSS 25 for analysis and data management. The collected data was first tested for assumptions, including normality, homogeneity, and outliers. Outlier tests were conducted to identify extreme data that could affect the analysis results. If significant outliers were found, further examination was conducted to determine whether the data should be retained or removed. After the outlier removal process, normality and homogeneity tests were conducted again. However, since the data remained non-normally distributed even after the outliers were removed, it was decided to retain the data and use non-parametric statistical tests as the appropriate analysis method.

The Wilcoxon signed-rank test was used to analyze differences within the same group (pretest and posttest). This test determines whether there is a significant change in scores before and after the intervention within a single group by comparing paired data. Meanwhile, the Mann-Whitney U test was used to compare the differences between the experimental and control groups. This test assesses whether two independent groups have different distributions, particularly when the data do not follow a normal distribution.

The conclusions were drawn based on statistical test results, primarily by examining the obtained p-value. If $p < 0.05$, the hypothesis was accepted, indicating a significant difference, whereas if $p > 0.05$, the hypothesis was rejected. The hypothesis in this study states that there is a significant difference in the enhancement of science process skills in early childhood between learning with PSSGA media and learning without this media.

The learning effects on both groups were analyzed to determine the effect size of the applied learning. The measurement of the learning effect size was analyzed based on the rank-biserial correlation (r). The calculation of the rank-biserial correlation (r) was conducted considering the sample size (N) and the Z value, as stated in Eq. (1). The interpretation of the magnitude of the effect size from the learning application is categorized into three categories: small effect size for $r = 0.1$, medium effect size for $r = 0.3$, and large effect size for $r = 0.5$ [53].

$$r = \frac{Z}{\sqrt{N}} \tag{1}$$

IV. RESULT

The data obtained from the study were first subjected to preliminary testing. This initial testing aimed to check the normality and homogeneity of the data. Normality testing was conducted using the Shapiro-Wilk test due to the relatively small sample size, which is suitable for this test. Meanwhile, homogeneity testing was performed using Levene's test. The results of these tests are presented in Table 3.

Table 3. Normality test and homogeneity test

Test	group	Normality Test			Homogeneity Test		
		Kolmogorov-Smirnova			Levene Statistic		
		Statistic	df	*p*	Statistic	df	*p*
Pretest	Control	0.197	28	0.07	39.774	56	0.00
	Experimental	0.204	30	0.03			
Posttest	Control	0.935	28	0.041	38.495	56	0.00
	Experimental	0.934	30	0.041			

Table 3 presents the results of the normality and homogeneity tests for each group. The conclusion regarding the data distribution is based on the p-value obtained from these tests. If the p-value is greater than 0.05, the data are considered normally distributed and homogeneous. Conversely, if the p-value is less than 0.05, the data are considered non-normal and non-homogeneous. The results indicate that the p-value is less than 0.05, suggesting that the data distribution in this study does not meet the assumptions of normality and homogeneity. Therefore, further analysis to examine differences in early childhood science process skills was conducted using non-parametric statistical tests.

A. The Influence of Learning Methods on the Enhancement of Science Process Skills in Early Childhood

Data The pretest and posttest results for each group were the data on the science process skills of both groups, which were obtained through tests consisting of pretests and posttests. The results of the pretests and posttests from each group were used as data sources in the analysis of the enhancement of early childhood skills. The results of the science process skills of both groups are presented in Fig. 4.

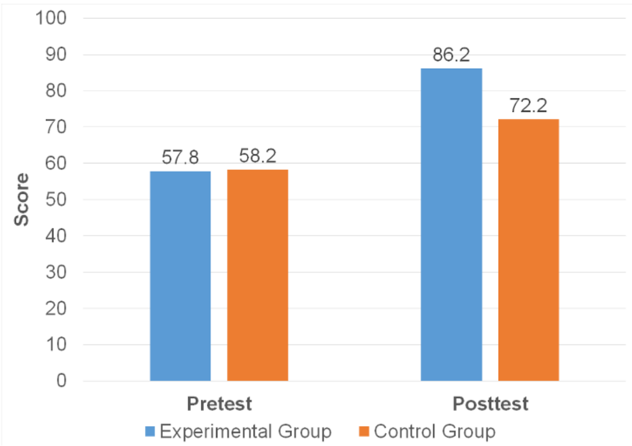

Fig. 4. Science process skills scores.

Fig. 4 showed an enhancement in science process skills in both groups. The control group obtained a pretest score of 58.2 and a posttest score of 72.2. Meanwhile, the experimental group had the same pretest score of 57.8, but their posttest score increased significantly to 86.2. The pretest and posttest results in the experimental group demonstrated a greater enhancement compared to the control group, indicating the effectiveness of using PSSGA media in enhancing early children's science process skills. The testing was conducted using the Wilcoxon test to investigate the effect of different methods in improving science process skills in early childhood. The Wilcoxon test results present the distribution of the amount of enhancement and changes in each student's test results and are used to determine the conclusion about the success of the implemented teaching method. The Wilcoxon test results for both groups are presented in Table 4.

Table 4. Wilcoxon test results

Information	Pretest- Posttest	
	Media PSSGA	**Media Picture**
Negative Rank	0	0
Positive Rank	30	30
Ties	0	0
Total	30	30
Z	−4.807	−4.647
p	0.000	0.000

Table 4 presents the results of the Wilcoxon signed-rank Test used to investigate the impact of the applied learning methods on improving early childhood science process skills. The Wilcoxon signed-rank Test results show that no participant in either the experimental group using the PSSGA media or the control group using the image media experienced a decrease in posttest scores compared to pretest scores, as indicated by a negative rank = 0 in both groups. In contrast, all participants experienced an increase in their posttest scores compared to pretest scores, with a positive rank = 30 and ties = 0, meaning that there were no participants whose scores remained unchanged.

The negative *Z*-values (–4.807 for the experimental group and –4.647 for the control group) indicate that the changes represent an increase in scores following the intervention. Additionally, the *p*-value = 0.000, which is smaller than 0.05, indicates that the enhancement is statistically significant in both groups. Therefore, it can be concluded that both the PSSGA media and the image media significantly contributed to the enhancement of early childhood science process skills. However, to determine whether the enhancement in the experimental group is larger than that in the control group, further analysis is required using the Mann-Whitney U test.

B. The Comparison 0f the Effects of PSSGA and Picture Media in Enhancing Science Process Skills in Early Childhood

Non-parametric statistical testing was performed using the Mann-Whitney U test to analyze the data in this study. The data obtained are presented in several variables, including the sample size (*N*), total score, mean rank, U-value, and *Z*-value. These variables are used to determine whether there is a significant difference between the experimental and control groups. The purpose of this Mann-Whitney U test is to test the hypothesis regarding the effect of the treatment on early childhood science process skills. The results of the Mann-Whitney U test are shown in Table 5.

Table 5. Mann-Whitney test results

Test	Result
Mann-Whitney U	406.000
Z	−6.551
p	0.000

The Mann-Whitney test results presented in Table 5 show a Mann-Whitney U value of 406.000 and a *Z*-value of −6.551. The negative *Z*-value indicates that the experimental group has a higher distribution of scores compared to the control group. The *p*-value of 0.000, which is less than 0.05, indicates that the difference between the two groups is statistically significant. Therefore, it can be concluded that there is a significant difference between the experimental and control groups in terms of the enhancement in early childhood science process skills.

C. The Effect Size of PSSGA in Enhancing Science Process Skills in Early Childhood

The effect of using PSSGA in enhancing science process skills was tested by analyzing data that includes sample size, mean, standard deviation, and *Z* value. This data was used to measure the extent to which learning with PSSGA influences the enhancement of these skills. To measure the magnitude of the effect, rank-biserial correlation (*r*) was used as the method for calculating the effect size. The results of the *r* value indicate the impact of learning with PSSGA media in enhancing science process skills in early childhood. The calculated *r* values were presented in Table 6.

Table 6. Effect size

Group	Postest				Effect Size
	N	**Mean**	**SD**	***Z***	**(*r*)**
Control	28	72.2	1.59	6.551	0.855
Experimental	30	86.2	4.08		

Table 6 shows the effect size calculated based on the *Z* value and the total sample size. The obtained *r* value was 0.855 in the large effect category. The results of this effect indicated that the difference between the experimental and control groups achieved a large effect in improving science process skills. This effect indicated that the use of PSSGA media in the experimental group significantly impacts the enhancement of science process skills compared to the control group.

V. Discussion

The implementation of learning with PSSGA and picture media contributed positively to improving science process skills in early childhood. Learning with picture media was able to enhance science process skills by providing positive enhancements for each child. On the other hand, learning with PSSGA also enhanced these skills, but the enhancement in the PSSGA group was greater compared to the picture media group in enhancing science process skills in early childhood.

This study shows that integrating PSSGA media with Minangkabau local wisdom can enhance early childhood science process skills. Based on the research conducted in Kindergarten in Payakumbuh, Indonesia, PSSGA media has proven effective in developing early childhood abilities in the five science process skills: observing, measuring, comparing, classifying, and communicating. Early childhood aged 5–6 years are in the concrete operational phase, which means that visual, game-based, and story-based learning media are highly suitable for their developmental stage [54]. Game-based story media provides a concrete learning experience for children, enabling them to relate science concepts to the real world [55, 56]. Furthermore, PSSGA media is easy to understand and captures early childhood attention, making it an effective tool for delivering knowledge and skills to young children.

The science stories in the PSSGA media introduce science concepts and integrate Minangkabau's local cultural values, such as making brown sugar, glutinous rice, and fermented buffalo milk. These activities involve children using their senses to recognize these traditional foods' shape, taste, and aroma. Early childhood observation skills are developed as children are encouraged to explore objects using various senses, including touch, sight, hearing, taste, and smell. Early childhood, ages 1–6 years need stimulation through sensory exploration to enrich their learning experiences [57]. These observation activities help children expand their science concepts related to objects and learning content [58]. Therefore, this PSSGA media conveys scientific knowledge and introduces an immersive cultural experience.

The elements of Minangkabau culture enhanced students' learning of science process skills through PSSGA media, which combines illustrations and culturally-based narratives to convey scientific concepts contextually. Desyandri [59], in his research, also revealed that integrating local culture enhances early childhood's contributions to learning. Learning that adopts the surrounding environment influences the enhancement of science skills in early childhood [60]. The concept of local wisdom material in Minangkabau culture connects scientific principles with everyday life, facilitating students' understanding.

The research results indicate that the elements of Minangkabau culture significantly contribute to enhancing science process skills. The philosophy of Minangkabau culture, which states that nature is the best teacher, reflects how the environment can be a valuable source of learning [61]. Through direct involvement in experiments, such as the traditional Minangkabau yogurt-making, students can develop the ability to formulate hypotheses, conduct experiments, and analyze data. For instance, by using conventional equipment made of bamboo as a container for storing buffalo milk, students are trained to hypothesize about the changes that occur when the milk is left overnight to undergo fermentation. Implementing local Minangkabau cultural wisdom plays a role in uncovering students' scientific abilities [62]. The messiness in the research also reveals that besides the elements of Minangkabau culture enhancing students' skills and abilities, these elements also contribute to improving students' attitudes [63]. Previous research supports the study's findings, indicating that cultural elements influence a deeper understanding of scientific concepts through direct experience.

The experience of preparing traditional Minangkabau cuisine allows students to practice science process skills through experiential exploration. In this regard, PSSG media is used to guide the learning process of these science skills. Research also reveals that Minangkabau culture, which is derived from natural knowledge, has great potential to be integrated into students' science process skills learning [64]. The integration of Minangkabau culture in learning not only trains scientific skills but also helps the younger generation to recognize, preserve, and appreciate their cultural heritage [65].

Sriwahyuni [66], in her research, reported that integrating Minangkabau culture into practical e-modules supports early childhood learning. However, this study contributes by reporting new impacts related to PSSGA media integrated with Minangkabau culture, which effectively enhances science process skills in early childhood. In addition to observation skills, PSSGA media teaches measuring skills by involving children in making traditional foods. Early childhood learn to recognize the tools and materials needed and estimate the time required to make brown sugar, glutinous rice, and fermented buffalo milk. Effective learning media stimulates early childhood to learn well, including measuring. Early childhood also learn about the proportions of ingredients and the number of tools used in the process. Presenting phenomena and activities directly involving early childhood helps provide a more concrete understanding of measurement concepts in science [67]. Thus, measuring skills become one process skill that develops using game-based media.

Comparing skills is also emphasized in learning through PSSGA media. Early childhood children are encouraged to recognize the similarities and differences in the objects used to make Minangkabau traditional foods. Early childhood can compare various tools and materials and the processes of making brown sugar, glutinous rice, and fermented buffalo milk [68]. Early childhood must be trained in science learning to compare steps and desired outcomes [15]. By comparing different objects or processes, children learn to understand basic science concepts [69]. PSSGA media provides an enjoyable and effective way for children to develop this skill through interactive games.

Furthermore, PSSGA media also teaches classifying skills by inviting children to categorize tools, materials, and steps involved in food preparation. In this case, children are expected to identify relevant categories of materials and steps in each process. Classifying skills are important in science learning because children learn to understand categories and relationships between objects. The classification process helps early childhood gain deeper knowledge about the properties of objects and materials used in experiments. Through games, early childhood can better understand the scientific concepts taught [70].

Communicating skills are the final skills developed through PSSGA media. Early childhood is encouraged to recount the process of making brown sugar, glutinous rice, and fermented buffalo milk and answer questions related to these processes. Science communication skills are important to help children express their knowledge and understanding [71]. In this media, early childhood can explain the processes they performed and describe the concepts they learned through speaking and questioning activities. This skill also contributes to the child's ability to interact with their social environment. Thus, communicating skills become integral to science learning through PSSGA media.

In the context of technology, PSSGA media provides distinct benefits for early childhood as children are already accustomed to interacting with devices such as smartphones or tablets. Technology can be an effective tool in learning, as it facilitates early childhood access to information and motivates them to learn [72]. Educational game-based media is also highly appealing to early childhood due to its enjoyable and interactive nature. Educational digital games provide an effective learning medium for early childhood as they integrate into their world [24]. Additionally, these educational games offer a more engaging and varied learning experience than conventional methods such as lectures or textbooks [73]. These results were evidenced by the effect size of the learning implementation using PSSGA media, which falls into the very large category of improving science process skills in early childhood.

In addition to the benefits for early childhood, the PSSGA media also provides convenience for teachers when implementing technology in learning. Teachers' ability to use technology is crucial in the 21st century [74]. This easily accessible and engaging media significantly supports teachers in delivering effective science lessons [75]. Learning aligned with technological developments will assist teachers in improving the quality of their teaching. Therefore, PSSGA media can solve the challenges teachers face in implementing enjoyable and engaging science learning for children.

In conclusion, using PSSGA media integrated with Minangkabau local wisdom has proven effective in enhancing early childhood science process skills. This media provides an opportunity for early childhood to learn fun and engagingly while introducing cultural values relevant to their lives. This media is highly suitable for wider application in early childhood science education based on the research evidence and existing theories. The PSSGA media also enriches the diversity of learning methods and positively impacts the development of early childhood science process skills in the future.

VI. Conclusion

The research results revealed that learning with the PSSGA method and picture media contributed to improving students' science process skills. Each group showed enhancement in students' science process skills. However, learning with PSSGA resulted in a greater enhancement. The study results indicate that the PSSGA media integrated with Minangkabau local wisdom positively affects early childhood science process skills. This demonstrates that this learning media effectively enhances early childhood science skills. The PSSGA media effectively trains early childhood science skills, which include observing, measuring, comparing, classifying, and communicating. These results are supported by the effect size of the PSSGA media implementation, which falls into the large category of improving science process skills in early childhood. These findings imply the importance of using innovative learning media integrated with local wisdom in early childhood science education. The PSSGA media can be an effective alternative to support the development of early childhood science skills development.

Although this study contributes to advancing knowledge in early childhood education, several limitations should be noted. First, the sample size in this study is relatively small, so future research is recommended to use a larger sample to enhance the generalizability of the findings. Second, this study has not yet explored the application of the Technology Acceptance Model (TAM) in early childhood education, providing an opportunity for further investigation in future studies.

Additionally, future research is encouraged to explore the application of this media in various aspects of early childhood development, including language skills, cognitive development, and gross and fine motor skills. Furthermore, studies could examine the impact of using similar media in regions with diverse cultural backgrounds to better understand its effectiveness.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

DE contributed to the development of the research idea, the development of the application or media used in this research, the preparation of the scientific article, and was part of the umbrella research; In this study, DE served as the developer of the model being tested, while the influence of the model was analyzed by students as part of a broader umbrella research; IAP contributed to data collection, data processing of the research, and the writing of the article; MD played a role in writing the article and assisted in processing the research data; all authors had approved the final version.

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