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The Impact of Digital Storytelling-Based Learning Environment on Young Children's Science Process Skills

Ali A. Al-Barakat [1, 2*], Omayya M. Al-Hassan [3], Rommel M. AlAli [4*], Nahla A. Ibrahim [4]

[1] *Department of Education, University of Sharjah, Sharjah 27272, United Arab Emirates.*

[2] *Faculty of Educational Sciences, Yarmouk University, Irbid 21163, Jordan.*

[3] *Department of Early Childhood, Queen Rania Faculty for Childhood, The Hashemite University, P.O. Box 330127, Zarqa 13133, Jordan.*

[4] *The National Research Center for Giftedness and Creativity, King Faisal University, Al-Ahsa 31982, Saudi Arabia.*

Abstract

The present study aimed at examining the effects of digital storytelling-based learning environment on children's science process skills such as observation, classification and prediction. A total of 238 children were involved and divided into an experimental group which was exposed to digital storytelling and a control group which was not exposed to digital storytelling. The data collection included interactive digital stories and tests to assess science skills and semi-structured interviews to gather children's feedback. The findings of the study revealed that digital storytelling has a positive effect on children's scientific skills and this was because the experimental group performed better than the control group in all the skills assessed. There was a significant improvement in the observation skills of children in that they were able to identify more details in natural phenomena. The classification skills were enhanced since children were able to arrange and categorize information using the structure of digital stories. The prediction skills were also enhanced, which showed that there was an enhancement in the critical in thinking early skills. It is recommended that childhood-based curricula incorporate digital story, and teacher training should include it as well.

Keywords:

Digital Storytelling;
Learning Environment;
Science Process Skills;
Learning.

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1- Introduction

Science process skills are important abilities of children in early education and are vital in the development of the scientific and cognitive abilities of children. These skills are observation, classification, measurement, prediction, experimentation, and analysis and are not only to be performed in laboratory experiments. Rather, they are valuable for a systematic approach to understanding and learning natural phenomena correctly. Through systematic processes, these conclusions are quite helpful in improving young children's abilities to gather data, analyze critically, and solve problems [1, 2]. These scientific challenges necessitate analytical thinking skills in children, helping them make decisions and be ready to practice scientific knowledge and skills in different contexts [3, 4].

Given these skills and their importance, educational reforms in science curricula emphasize that children should not be confined to science learning environments that depend on the transmission of theoretical knowledge. Instead, they should be engaged in learning environments in which science process skills are employed as tools for thinking scientifically to enable children to pose and address problems effectively [5-7]. In particular, current active learning environments are concerned with both the learning of scientific knowledge and its application in everyday life. This

* **CONTACT**: aalbarakat@sharjah.ac.ae; ralali@kfu.edu.sa

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improves children's analytical skills and practical skills and lets them deal with their environment in a scientific and systematic way. Therefore, science learning environments for children are seen as integrated educational environments that develop their cognitive, skill-based, and affective dimensions, as scientific education is recognized as an essential component of critical thinking and scientific-based decision-making [7-9].

With the fast pace at which science and technology are developing, it is important to build learning environments that are grounded on new learning strategies that are consonant with these technological developments. The traditional learning environments are not sufficient to prepare children for the cognitive demands of the digital age; hence, new strategies are needed to help children learn science process skills in a more creative way. One of these learning strategies involves integrating 'digital storytelling,' a method that integrates technology into the learning settings through the use of interactive videos and multimedia. This technique allows children to be more interested in the content they are being taught, especially in science learning, as they are able to present their ideas on how a given scientific concept should be planned, presented, and understood in a progressive manner, which encourages understanding and analysis [9-12].

The major strength of the concept of "digital storytelling" is that it tries to combine the best of educational technology with the best of the ancient art of storytelling, which is part of our cultural heritage. This is evident in that it enhances children's motivation and interest in scientific topics, hence improving the understanding of scientific concepts and their application in everyday life. Additionally, this method allows children the opportunity to learn basic scientific processes such as observation, analysis, and experimentation in an interactive form, thus enhancing the effectiveness of the learning process in the digital society. Therefore, integrating digital storytelling with traditional scientific processes in an innovative way offers a complete learning experience that takes advantage of the benefits of learning along with the modern technologies [9, 10, 13-15].

This innovation has been well applied at all learning levels as a learning method and a tool for teaching. It increases the amount of interaction of children and helps the teachers to use creative ways of teaching and provide improved teaching practices. Although storytelling is not a new approach in the field of education, especially in early childhood education, digital storytelling is still a fairly recent evolution [3]. This paper also shows how storytelling is not only part of human nature to express dreams, communicate, and pass on knowledge through stories [7, 9, 10]. Therefore, digital storytelling is an organized and sequential way of presenting scientific knowledge to make it an effective method of conveying complex scientific principles. It supports the development of ideas, sparks curiosity, and offers a more coherent form of scientific content. Thus, it minimizes the level of ambiguity and enhances learning [1, 9-11].

In addition to the cognitive benefits, digital storytelling supports experiential learning, forming logical connections among ideas, and developing research skills [1, 4, 9]. It also helps in achieving the learning goals of broadening the cultural awareness of children, inculcating sound educational values, promoting creative thinking, and improving language skills. The imagination and creativity of children are also enhanced by the psychological and emotional aspects of digital storytelling. It also improves language skills, communication and expression, and reading and writing skills and therefore enhances child interaction in classrooms and in the wider community. Stories are accompanied by different emotional responses, for example, happiness in happy stories and sadness in moving stories, which makes the learning process more effective [9, 16].

Digital storytelling has been successfully used in recent studies to improve engagement, creativity, and the critical learning thinking process skills within the educational setting [17-20]. However, although there is an increasing amount of research on its effect, there are still some gaps in knowledge on how to use it effectively, especially in different fields and at various levels of education. This review offers an overview of the available research on digital storytelling, identifies research gaps, and outlines possible directions for future research.

Shi & Cheung [21] investigated how digital storytelling could benefit English language learning and found a positive effect on the development of the four language skills: listening, speaking, reading, and writing. This study showed that digital storytelling prompts students to create more elaborate stories and thus improves engagement and critical thinking. Although these findings are encouraging, additional research is needed to determine the effect of digital storytelling on language skills across various proficiency levels and in different cultural environments.

High school students, in particular, prepare for exams with the help of digital storytelling, as revealed by Chen & Chuang [22]. The analysis of their study shows that collaborative digital storytelling activities do enhance students' ability to analyze information and to offer more profound discussions. This study does not contribute to the discussion of how digital storytelling affects other cognitive skills such as memory retention or problem solving. The unexplored cognitive outcomes of digital storytelling, especially in subjects that need analytical thinking of a high order—mathematics and science—should be investigated in future research.

In a related study, Lim et al. [23] also described the application of digital storytelling to boost self-directed learning. This approach was seen to improve students' creative and critical thinking skills as well as their digital literacy skills. However, its application was mostly explored in higher education with minimal consideration of its effectiveness in primary and secondary education or early childhood education. This is a gap in the knowledge of how pre-academic learners interact with stories and how digital storytelling can be properly incorporated into different levels of education.

Cruz-Lorite et al. [24] studied the use of digital storytelling as a method for promoting critical thinking skills in preservice preschool teachers. This study, which involves 119 preservice teachers at the University of Malaga, Spain, found that creating digital stories based on the daily lives of children does enhance critical thinking skills. Nevertheless, the study revealed the existence of positive aspects (e.g., motivating effects of digital storytelling) and negative aspects (e.g., puzzles, such as how to translate scientific knowledge to children's age levels, and the importance of distinguishing between information from credible and unreliable sources) of the method. These findings support the need for further exploration of how digital storytelling can be implemented to meet the needs of young learners.

Despite the significant benefits demonstrated in various studies regarding the effectiveness of digital storytelling in enhancing different aspects of learning, there are notable gaps in the current literature, particularly concerning the application of digital storytelling in early childhood education and the improvement of young children's science process skills. Most prior studies have focused on fields like language education or social sciences, leaving a gap in understanding how young children, especially in early educational stages, can benefit from learning environments based on digital storytelling to enhance their science process skills.

A key gap is the limited research on using digital storytelling to develop science process skills in young children during early education stages. While some studies have addressed the impact of digital storytelling on critical thinking or creativity, there is a pressing need to understand how such digital environments can foster skills like observation, hypothesis testing, experimentation, and analysis in early educational contexts. Moreover, it remains unclear how digital storytelling environments can be adapted to meet the needs of young children. More research is required to explore how these digital environments can be designed to support the development of fundamental science skills while catering to the cognitive abilities of young learners.

2- Problem of the Study

The problem of this study arises from field observations of science learning environments, which indicate a weakness in children's engagement with primary scientific processes. This is mostly due to the lack of adequate teaching techniques and strategies that can help in improving the learning of such processes. Several research works [9, 12] have revealed that the conventional science education systems, which mainly involve the transfer of knowledge, do not allow the children to go through the scientific processes effectively. Therefore, the children find it difficult to acquire fundamental skills that are necessary in order to foster critical scientific thinking and scientific problem-solving skills, which include observation, classification, measurement, prediction, experimentation, and analysis.

Although there is a general consensus on the fact that scientific processes help in the development of analytical and systematic thinking, the traditional methods of teaching, which focus on learning by heart, do not help the children to deal with scientific content in a practical manner or use these skills in real life. Thus, there is a clear need for new pedagogical approaches that can help children interact with scientific material in a more meaningful manner. One of the strategies that have been proven to be effective is 'Digital Storytelling' which involves the use of multimedia and technology in teaching. This method can encourage children to explore scientific concepts in an engaging and organized manner.

The main purpose of this study, therefore, is to explore the effect of integrating digital storytelling into science education on children's acquisition of primary science skills. The study also seeks to assess whether digital storytelling is an effective method of teaching that can stimulate children, encourage them to learn and develop science process skills, and put these skills into practice in their daily lives. The major research questions guiding this study are as follows:

- What is the impact of a digital storytelling-based learning environment on children's acquisition of science process skills?
- What improvements can be observed in children's acquisition of science process skills in light of their learning in a digital storytelling-based learning environment?

3- Research Methodology

3-1- Study Design

The current study employed a quasi-experimental design in order to examine the effect of digital storytelling based-learning environments on enhancing children's learning of science process skills as compared to conventional teaching methods. This study is especially relevant in the context of identifying effective methods for developing new learning approaches that could improve the quality of teaching and learning practices.

The research design involved the partitioning of the sample into two groups, namely the exposed experimental group, in which digital storytelling was based on learning environments, and the control group, which was taught through the traditional methods. A unified pre-test was administered to both groups before the intervention to measure their initial science process skills. This step ensured that both groups were equivalent in their initial performance, thereby enhancing the reliability of the results and facilitating a clear comparison of the effects of digital storytelling-based and traditional teaching methods.

During the instructional phase, the experimental group was taught using digital storytelling environments, integrating digital narratives as a tool to stimulate learning. Conversely, the control group received instruction through conventional methods, such as verbal explanations and textbook-based teaching. At the end of the teaching period, a unified post-test was given to both groups in order to assess the changes in the children's scientific process skills. This test was designed to determine the success of the teaching approach and assess the impact of the instructional methods on fostering learning achievement.

The quasi-experimental design afforded a systematic approach in analyzing the effects of digital storytelling-based learning environments. Thus, the study had both pre-tests and post-tests to help measure and assess the effectiveness of such environments in enhancing children's scientific skills. Additionally, this design offers empirical evidence supporting the adoption of modern, interactive teaching approaches that foster engagement and improve the overall learning experience. The flow of this research design is presented in Figure 1.

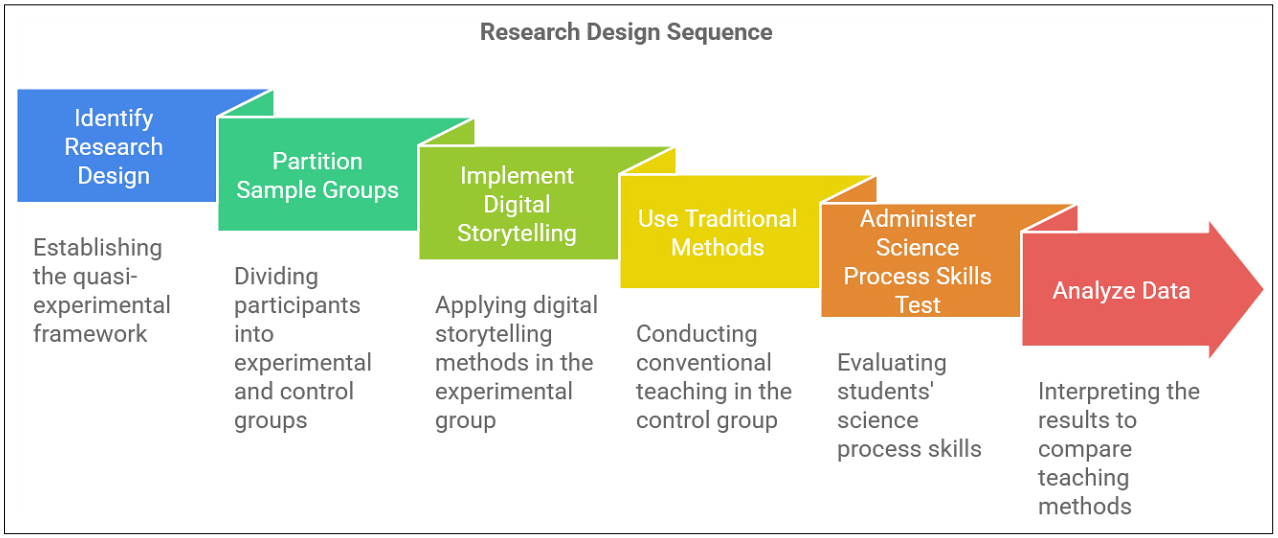

Figure 1. Research design

3-2- Study Sample

A purposive sampling of 276 children of ages 7–8 years was made from six public schools within the educational district of Northern Jordan. The selection was made based on certain criteria to ensure the learning environment was congruent with the study. The criteria included the willingness of the school administration and teachers to work with the researcher as well as the availability of the devices and technologies for a digital storytelling-based learning environment. In fact, these schools had received technological support from UNICEF to improve children's learning.

To ensure consistency and minimize variability in the sample's demographic variables, participants were chosen from a single geographical area, specifically a rural region in northern Jordan. This approach was intended to avoid potential heterogeneity between groups. Furthermore, all participants were selected from the same educational level-second-grade students in the childhood stage-ensuring that all children were within the average age range of seven and a half years (7-8 years). This strategy further ensured that the academic levels of the participants were similar, as the children in both the experimental and control groups were distributed across three performance levels: high, average, and low. By carefully controlling these variables, the study aimed to maintain homogeneity within the sample, ensuring that any observed effects were due to the intervention rather than demographic or academic differences. As a result, the sample population was relatively homogeneous, making the study's findings more generalizable.

The sample was equally divided into two groups. The control group was made up of 138 children taught using traditional teaching procedures, while the experimental group of 138 children participated in digital storytelling-based learning environments. This split was to enable a structured analysis of the effects of both approaches to teaching and hence identify the advantages of using digital storytelling in early childhood education.

3-3- Digital Storytelling-Based Learning Environment

The following are the steps that were followed to develop the digital storytelling-based learning environment:

- ***Setting the general goal of the learning environment***

The overall aim of developing the digital storytelling-based learning environment was to help the children appreciate water and its role in the life, learn about the water cycle in the environment, identify different uses of water and make the children realize the importance of water conservation.

- ***Choosing the learning unit***

The learning unit that has been chosen is “Water in our lives” because it is a primary idea that can help the children to comprehend the real world around them. This unit plays a very important role as it is the first step towards learning some of the important scientific concepts like the water cycle, the states of water, and the need to conserve water and natural resources.

- ***Defining learning outcomes***

The learning objectives were designed to be specific and measurable, including:

  - List the three states of water, which are liquid, frozen state (ice), and gas in the form of vapor.
  - Describe the water cycle in nature for children in a simplified manner (evaporation, condensation, precipitation).
  - Illustrating the different ways through which water is used in our daily lives, for instance, cooking, cleaning, irrigation, and drinking.
  - Proposing water conservation practices and strategies.
  - Fostering positive attitudes toward preserving water resources.

- ***Writing the script and preparing the scenario***

The script narrated a story about a child or cartoon character exploring the significance of water in daily life. The scenario depicted the character’s discovery of the water cycle in its environment; it could be based on real or fictional experiences, segmented into stages such as visiting a river, observing evaporation, seeing clouds, and experiencing rainfall.

  - *Scenario*: The story starts when a child observes that the plants in his or her garden require water and the child decides to investigate how and where the water comes from and how it gets to the plants.
  - *Script*: The narrative starts with an engaging line, such as, “On a sunny morning, Ali decided to uncover the mystery of the water that nourishes his flowers.”

- ***Character design and development***

The story featured a main character (e.g., "Ali") alongside supporting characters such as "Sarah" (representing water), "Adam" (representing clouds), and "Sawsan" (representing the sun). A fictional character, “Drop,” a water droplet, accompanied Ali on his journey, explaining the water cycle.

  - *Main character*: Ali, the curious child.
  - *Supporting characters*: "Drop," the water droplet that explains scientific concepts; "Sawsan," the sun, discussing evaporation; and "Adam," the cloud, explaining condensation.

- ***Selection of digital media***

Digital media were carefully chosen to enhance children’s understanding of scientific concepts, including:

  - *Illustrations and photographs*: Depicting the water cycle, plants, and rivers.
  - *Sound effects*: Simulating flowing water, thunder, and rainfall.
  - *Videos*: Animated clips demonstrating evaporation, condensation, and precipitation in a simple and engaging manner.

- ***Utilizing digital storytelling tools***

Tools such as *Powtoon* and *Canva* were employed to compile texts and media into interactive formats. Visuals and texts were organized to engage children, with interactive activities and questions encouraging participation. Software

like *Adobe ''Spark''* was used to add visual effects, integrate illustrations, and create a cohesive story sequence. The narrative started with simple text and illustrations, followed by a video explaining the water cycle and an interactive audio segment with questions about the story's content.

- ***Validation of the learning content***

A panel of specialized reviewers from Jordanian universities in the fields of science education, early childhood technology education, and artificial intelligence was formed to review the objectives and content of the digital stories, ensuring their alignment with the appropriate educational standards set by the Jordanian Ministry of Education. Additionally, the committee verified how well the design of the digital stories considering the target age group by assessing their alignment with the psychological and cognitive characteristics of students aged 7-8 years. In this context, the panel evaluated the digital stories to ensure they met the defined educational objectives and adhered to the required educational standards. The suggestions and feedback provided by the experts were applied to the content to make it more aligned with the desired learning outcomes. As a result, it was ensured that the selected stories were not only age-appropriate but also effective in enhancing learning outcomes and achieving the intended educational goals.

- ***Development of lesson plans***

The lesson plans were developed for teachers to implement by means of digital storytelling. All these plans were developed in accordance with the preparation model suggested by the Ministry of Education and based on the model of teaching that places a teacher in the role of a guide and the child in the role of an active participant in the learning process.

- ***Validation of lesson plans***

The lesson plans were assessed by science educators experts, early childhood educators experts, and information technology educators experts. Suggestions from the feedback were used to make the procedures clear and feasible and all the suggestions were implemented in the final version so that they could be used in classrooms.

- ***Teacher training and piloting digital stories***

The lead researcher trained teachers from the experimental group to implement digital storytelling-based learning environments. The training included using digital stories similar to those developed for the study. Three digital stories were piloted in classrooms during integrated lessons on the importance of water. Interactive activities, such as drawing the water cycle or retelling the story with illustrations, followed the story presentations.

This phase was very useful because it revealed the following as potential challenges that might be of concern to both teachers and students when dealing with digital storytelling environments. The main challenge was that some teachers and some students were technically inexperienced and therefore unable to use digital tools properly. To this end, comprehensive technical training was provided before the digital activities were implemented, and technical support was readily available during the course of the process.

Additionally, some students found it difficult to concentrate during the digital activities for long, especially since they were not used to technology in their traditional learning environments. This challenge was overcome by dividing the activities into shorter sessions and including frequent breaks to help keep students focused and interested. These techniques allowed every participant to have a useful and systematic learning experience without being constrained by the limitations they may have in utilizing digital storytelling environments.

3-4- Science Process Skills Test

The science process skills acquisition test was developed to evaluate children's learning while studying the unit "Water in Our Lives" in the digital storytelling approach. The purpose of the test was to measure how well children can use the primary science process skills to help them comprehend and examine phenomena using stories told through digital media as instruction.

The first copy of the test had only 23 questions, which were developed to measure a set of target science process skills. In order to check the relevance and correctness of the questions, the test was evaluated by a group of experts in the fields of education and science. The questions were examined by the experts to make sure that they were in line with the objectives of the test, verify content validity, and check how appropriate they were for the scientific concepts measured. Following a thorough review, the test underwent revisions to address expert recommendations aimed at enhancing clarity, reducing redundancy, and ensuring comprehensive coverage of primary science process skills, including observation, classification, and prediction. The final copy of test comprised 20 multiple-choice questions, each offering four answer options.

These questions are designed to assist children in showing their mastery of the necessary scientific skills. The questions were of three categories: observation skills (7 questions), classification skills (7 questions), and prediction skills (6 questions). The maximum score for the test was 20 points, 1 point for each correct response. The science process skills assessed in the test are described as follows:

- ***Observation:*** Using sensory input (senses) to collect data on phenomena, for example, water properties under various conditions for children.
- ***Classification:*** Arranging items or phenomena in order of their properties, for instance, categorizing water into different types based on their properties.
- ***Prediction:*** Formulating hypotheses to pose what may happen in the future given the existing circumstances or previous experiences, such as guessing what happens to water when the temperature changes.

3-5- Validity and Reliability of the Test

The validity of the test was established through a panel of experts comprising educational science professors from Jordanian universities in science curricula, teaching methodologies, educational technology, and measurement and evaluation who evaluated for the clarity, test for how well the content of the test is related to the "Water in Our Lives" Experts' unit, feedback for led children's to cognitive key levels, revisions, and including: for removing alignment overly with challenging the questions, framework changing of items science to process better skills. Align with children's comprehension, and refining response options to be consistent with age-appropriate language.

The test was given to a pilot group of 25 people in order to establish the needed time to complete the test, to check how clear the test items were, and to compute the coefficients of the test's reliability. When the results of the test were analyzed, it was found that the average time that was required to complete the test was 45 minutes. This was done by adding the time taken by the fastest and the slowest person to complete the test and then dividing the sum by two. Reliability analysis was performed employing the Omega coefficient and coefficient alpha, where the resulting coefficients were 0.933 and 0.929, respectively, providing evidence of high internal consistency.

To verify the structure of the test for observation, classification, and prediction, a confirmatory factor analysis (CFA) was performed to assess and verify the factorial structure of the instrument. As shown in Figure 2, the hypothesized model, consisting of 20 items distributed across three dimensions, was constructed and analyzed, and the construct validity of the instrument was confirmed.

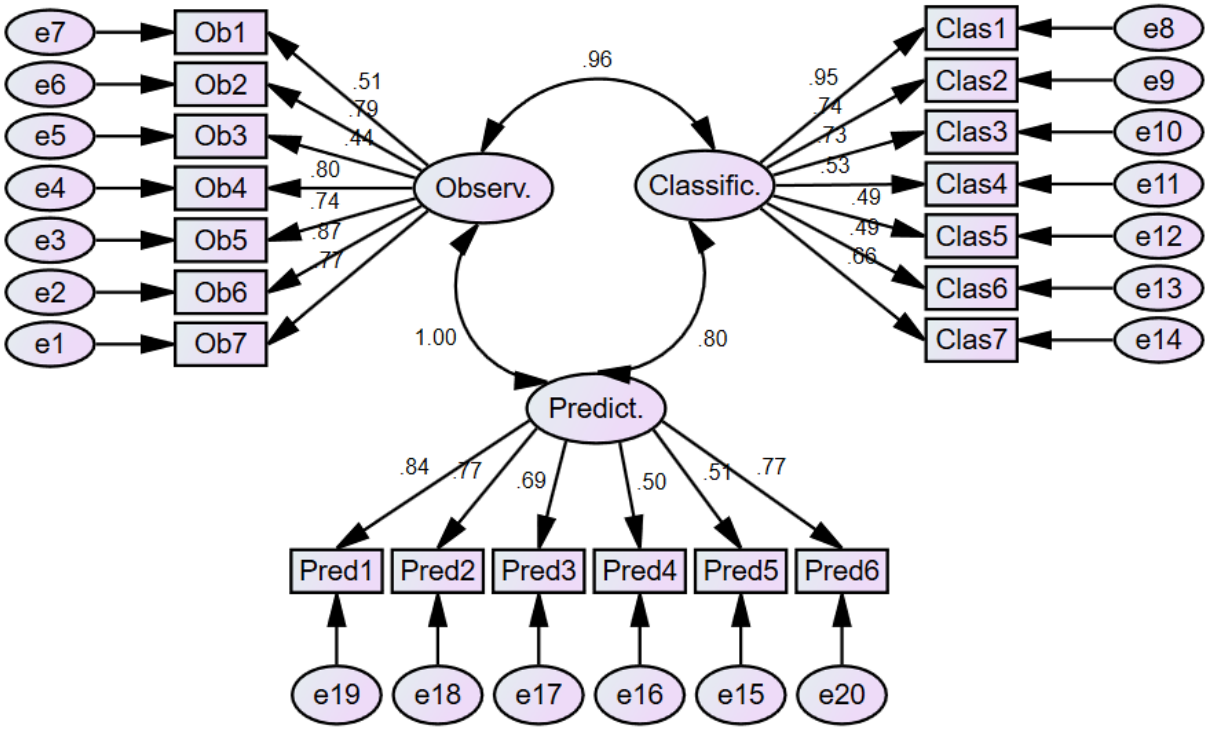

Figure 2. Results of the CFA of the model adopted for the relationship between the test items and dimensions

This is described in Figure 2, which shows the factor loadings of each item within its dimension. The analysis revealed that each item has a high factor loading within its dimension, hence indicating strong dimensional alignment. Moreover, the results showed that there were strong correlations between the dimensions of the test and the correlation

coefficients computed to confirm this positive relationship between the dimensions. Furthermore, internal structural validity indicators were examined to further support the CFA results. These indicators showed that the proposed model is consistent with the data and meets the validity criteria of this study. The findings thus verify the stability and reliability of the model in capturing the relationships between the test items and their dimensions.

3-6- Data Collection and Analysis Related to Science Process Skills Test

Before data collection, teachers in the experimental group received extensive training on how to use the digital storytelling-based teaching method. This training included practical demonstrations on creating an interactive digital story that includes text, images, videos, and sound effects with the goal of engagingly and effectively presenting learning material. The focus was on making sure that these digital stories could be properly incorporated into classroom activities by the teachers while ensuring they are aligned with the curriculum objectives for children aged 7–8 years.

After the training, a pre-test was administered to the participants in both the experimental and control groups to measure their initial performance in science process skills. The pre-test that was to be done at the beginning of the study was to assess the two groups as if they were equivalent in some way, and any differences that might be seen later on could be attributed to the digital storytelling strategy and not to some other variable. Then, the mean scores and standard deviations of children's pre-test results in both groups were calculated. To compare the means at a significance level of ($\alpha \leq 0.05$), a t-test was conducted to determine if there were statistically significant differences between the groups at the start of the study. This was presented in Table 1.

Table 1. The t-test results for group equivalence verification

Group	No.	Mean	St. dev.	df.	t-value	Sig.
Experimental	138	7.86	1.76	236	8.76	0.456
Control	138	7.98	1.89			

From Table 1, 0.456, the p statistical value, shows there are no significant differences between the experimental and control groups during the pre-test phase. This equivalence of the study is reliable because it demonstrates that any differences seen in the post-test must be due to the digital storytelling strategy and not from the pre-existing different levels of achievement.

This research was conducted over seven weeks, when the digital storytelling approach was incorporated in five classroom sessions per week, and each session was 45 minutes for a total of 35 sessions. In these sessions, the science process skills, such as observation, prediction, and classification, among others, were to be improved in the experimental group that was exposed to the digital storytelling environments in order to improve their understanding of science concepts. All this was done through the use of multimedia resources in the lessons in order to enhance the learning process to suit all the learning styles. There was an intervention, and to check the effect of the intervention on the children's science process skills, the post-test was given to both the pre-test groups, but in the same way as the pre-test and under the same conditions. The data collected from these tests were analyzed using SPSS, and a t-test was performed to see the difference in the mean score of the experimental and control groups to determine the impact of digital storytelling on the science process skills of the experimental group.

3-7- Semi-Structured Interview

The purpose of the semi-structured interview in this research was to gain deeper insight into how children's acquisition of science process skills has been enhanced through the process of learning in digital storytelling-based learning environments. Interviews were conducted with thirty-five children from the experimental group to understand the role of digital storytelling in their learning of science skills. The interview schedule was developed based on the researchers' practical experience in the education field. The questions in the interview schedule aimed to reveal how digital storytelling impacted children's acquisition of science process skills, such as observation, measurement, and prediction, which are fundamental skills for learning science in early childhood, as well as their understanding of specific scientific topics.

The initial copy of the interview schedule comprised five questions. After review by experts, the interview schedule was reduced to three main questions:

- Were you able to learn science after using digital storytelling? Can you tell me about a situation where this happened?
- Do you think digital storytelling helped you learn about the topic of water in our lives better? What topics did you find noticeable improvement in, and how?
- Can you give an example of how you applied what you learned from digital storytelling in your daily life? How?

To ensure the accuracy of the questions and what the study's objectives are able to identify, the interview schedule was validated by a panel of specialists in early childhood education, science education, digital technology, measurement, and evaluation. The schedule was also piloted on 8 participants who were excluded from the study sample to provide data that is related to the interview's objective. The semi-structured interview was chosen because it allows the researcher to get in-depth and flexible responses and gives the respondent the opportunity to delve deeper into the participants' responses for clearer exploration (Appendix I).

3-8- Data Collection of Semi-Structured Interviews

Based on the level of improvement in science process skills during the digital storytelling-based learning activities, thirty-five children from the experimental group were selected to participate in the interviews. To increase the credibility of the interview sample selection, the children were sorted into three groups based on the observed level of improvement: high, medium, and low in science skills. This classification ensures sample diversity and includes children who exhibit a mix of improvements.

First of all, the parents' consent was obtained for the interviews from the children. The purpose of the interview and the fact that the information provided would be kept confidential were explained to all the participants and their parents. The interviews were, for the most part, audio recorded and transcribed immediately to guarantee that the information that was derived from them was very accurate. The length of the interviews was 20-25 minutes per child. The transcribed texts were sent to the participants and their parents to ensure that the responses were accurate. Once the transcripts were reviewed, additional questions were asked to check for accuracy of information and to see if there was anything the participants wanted to either add or modify. All participants were satisfied with the recorded responses.

3-9- Data Analysis

After the interviews, the texts were analyzed to categorize the data into main and subcategories of the different aspects of improvement in science process skills, such as observation, classification, and prediction. First of all, criteria that describe the progress in these skills were identified based on children's responses and their interaction with learning environments based on digital storytelling. The data of the study were then classified into main categories of areas for improvement, with sub-categories calculated based on the responses.

4- Results

4-1- Results of the First Question

The goal of this question was to determine whether or not digital storytelling-based learning environments are effective in improving and acquiring science process skills of children. To meet this objective, the arithmetic means and standard deviations of participants' performance on the science process skills test were calculated based on the group variable (experimental or control). The result of the study can be represented in Figure 3:

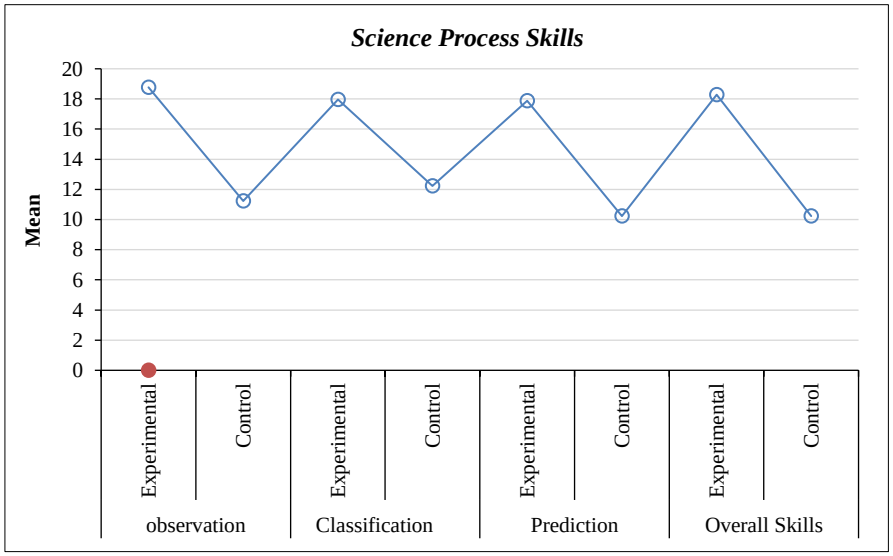

Figure 3. Comparison of the performance between experimental and control group students on the science process skills test

This shows the mean scores of science process skills (observation, classification, prediction, and overall skills) of experimental and control groups in Figure 3. The experimental group outperforms the control group in all skills, with particular emphasis on observation and prediction. This means that the intervention that was applied to the

experimental group in a positive way affected their science process skills, and thus the method of learning used for the experimental group is more effective than the traditional method used on the control group. The detail of the statistical values supporting these findings is presented in the statistical analysis in Table 2.

Table 2. T-test Results of the Participants' Performance on the Science Process Skills Test Based on Group Variable

Science Process Skills	Group	No.	Mean	St. Dev.	T. Value	df.	Sig.*	ETA square (η^2)
Observation	Experimental	138	18.77	1.77	8.049	236	0.003	0.40
	Control	138	11.23	1.94				
Classification	Experimental	138	17.97	1.23	7.035	236	0.002	0.43
	Control	138	12.23	1.96				
Prediction	Experimental	138	17.87	1.13	10.57	236	0.001	0.45
	Control	138	10.23	1.67				
Overall Skills	Experimental	138	18.27	1.26	10.446	236	0.000	0.47
	Control	138	10.23	1.93				

* Significance level (p.≤0.05)

The results presented in Table 2 show a significant positive effect of digital storytelling-based learning environments on enhancing science process skills in children. The experimental group that was trained with digital storytelling tools showed better results in observation, prediction, and classification skills when compared to the control group. For example, in observation skills, the experimental group achieved an average of 18.77 with a standard deviation of 1.77, while the control group achieved an average of 11.23 with a standard deviation of 1.94. The difference between the means was 7.54 points, which indicates a high effect of digital storytelling in enhancing the observation skills of children. This difference was statistically significant (T = 8.049, p = 0.003), thus indicating that the outcomes were not by chance, but they actually were influenced by the use of digital storytelling in enhancing observation skills.

As for classification skills, the experimental group also had better performance than the control group; the mean score of the experimental group was 17.97 with the standard deviation of 1.23, and the score of the control group was 12.23 with the standard deviation of 1.96. The difference between the means was 5.74 points, which shows that the experimental group has improved the classification of information. A paired samples t-test was computed to determine which differences in means were statistically significant (T = 7.035, p = 0.002); this indicates that digital storytelling enhanced the participants' classification skills.

For prediction skills, the experimental group had better results than the control group, as it had an average score of 17.87 and a standard deviation of 1.13, while the control group had an average score of 10.23 with a standard deviation of 1.67. The mean difference was 7.64, which shows that the experimental group had significantly improved on the prediction skills that were being measured. The differences were statistically significant (T = 10.57, p = 0.001); it therefore proved that digital storytelling helped in improving the prediction skills.

Across all the science process skills, the experimental group average was 18.27 with a standard deviation of 1.26, and the control group average was 10.23 with a standard deviation of 1.93. The difference between the means was 8.04 points, indicating an overall improvement in all the science process skills measured in the study. The differences were also statistically significant (T = 10.446, p = 0.000), which confirms that digital storytelling-based learning environments had a very positive effect on increasing children's science skills across all areas.

To determine the effect of game-based digital learning on science process skills assessment, eta squared (η^2) was calculated as a measure of effect size. The eta squared values were as follows: 0.40 for observation, 0.43 for classification, 0.45 for prediction, and 0.47 for the overall performance score in the study. This suggests that 40% of the variance in observation is explained by digital storytelling, with the remaining variance attributed to other uncontrolled factors. For classification, 43% of the variance is explained by digital storytelling, 45% of the variance in prediction, and 47% of the variance in overall science process skills is explained by digital storytelling. These results show that learning by digital storytelling is effective in increasing science process skills in students across the various skills assessed.

These results show that a digital storytelling–based learning environment is a useful tool for increasing primary science process skills in children. The significant differences in means between the experimental group and the control groups across all measured skills reveal the positive effect of digital storytelling on observation, classification, and prediction skills. The statistical analysis, which gave significant results (all p-values were less than 0.05), supports that these improvements are not by coincidence but as a result of using a digital storytelling-based learning environment.

4-2- Results of the Second Question

This question aims to reveal the improvements in children's acquisition of science process skills in light of their learning in digital storytelling-based learning environments. To achieve this, 35 interviews were conducted with members of the experimental group. The responses of the children to the interview questions indicated an improvement in the science process skills of children who learned in digital storytelling-based environments. The data showed a clear positive effect of digital storytelling on the development of these essential skills. The improvements can be presented according to science process skills as follows:

- ***The Manifestations of Improvement in the Observation Skill***

Responses from 34 children, representing 97.1% of the participants, revealed that digital storytelling-based learning environments contributed significantly to improving the children's observation skills. Data analysis results showed that the improvements in children's learning were evident in their ability to observe small changes that might not be easily visible in traditional learning environments. Digital storytelling, with its interactive and visual content, provides a rich environment that encourages children to pay closer attention to scientific details and enhances their interest and engagement in observing natural phenomena. For example, one child mentioned:

> *"I can notice things around me better, like how the water changes when I put it in the fridge. I can see the changes more easily."*

This quote is not only information for children but also stimulates how digital storytelling gets them to pay more attention to what happens around them. The digital content enhances their ability to notice environmental changes, precisely when, for example, one can see water being frozen into ice in the fridge, a simple yet powerful example of activating observation skills. Another response stated:

> *"Hmm …, before, I couldn't notice the changes in things quickly, but after I heard the story, I can notice everything, like when we see how the snow melts."*

The above quote is a good example of how children are able to create observations about slow environmental changes like the melting of snow. In conventional learning situations, such phenomena are often walked through, with the children not paying much attention to or asking fewer questions about the specifics of the process. This shows how digital storytelling can focus on the differences that might be hard to notice in small increments in traditional learning environments. However, the other child's response is as follows:

> *"Now, I notice everything, like water when it gets colder or when I put it in a clear cup.*"

Through sensory skills, children were able to identify changes that may be slight or almost undetectable in the physical world. Interaction with digital storytelling content improved children's sensory awareness and made the children more sensitive to slight changes in their environment, such as water temperature, color, or state. Thus, if a child is able to distinguish slight differences in water temperature or the color of a substance, then it has developed useful scientific skills that can be used in everyday life.

- ***The Manifestations of Improvement in the Classification Skill***

The responses of 32 out of 35 children (91.4%) revealed that digital story-based learning environments have a significant effect on improving their classification skills, which are crucial skills for organizing knowledge and understanding scientific processes. Therefore, the application of digital story environments improved the classification skills of children in a way that they could use in different life situations and in scientific contexts to sort items by their characteristics. One quote that illustrates the effect of digital stories on children is:

> *"In the story, I learned how to distinguish between fresh water and salty water, and then I understood why fresh water is better for drinking."*

Through this quote it is shown that digital stories helped children to categorize water into two kinds of water, fresh and salty, and this is a simple way to improve cognitive organization skills. In this case, using digital stories, children were able to classify elements in a logical manner, which shows that this type of learning is very effective in ordering elements correctly.

Through data analysis it was also found that another aspect of the improvement in classification skills of children through digital story environments is guiding children to understand the precise criteria that assist in the classification process. As one of the quotes stated: "In the story, they taught us how to filter salty water so we can drink it. If the water is salty, we need to remove the salt before drinking it." This response shows that the digital story did not only teach children how to classify but also what criteria to look for in classification. The story taught children how to classify water based on health and environmental standards, which improves children's scientific understanding of the environment and its use in everyday life.

Through data analysis it was found that another feature of the improvement in classification skills was the simplification of complex scientific concepts and transforming them into more understandable forms. As one response stated:

"Now I can put things in their correct places. The story helped me understand how everything needs to be in the right place to avoid mistakes."

From the provided quotes, it can be seen how digital stories assisted children with systematic sorting in an explicit way. more Digital stories are a form of presentation where information is put across in a sequence, and this makes it easy for children to receive and understand scientific concepts in the simplest and most accurate form. Such learning is not only informative but also beneficial in developing the critical thinking abilities of children and having them apply sorting skills in real-life situations.

In addition, from the interview analysis, it can be seen that a large part of the digital story's effect on improving sorting skills is through enhancing the sensory skills of children, whereby they are able to identify and sort objects on the basis of certain physical characteristics or properties, as depicted in one of the quotes:

"The story taught us how to distinguish between things that can be drunk and things that cannot, like salty water. Before learning from the story, I did not know how to classify water."

This highlights how digital stories enable children to classify information accurately, teaching them how to relate classification to scientific standards, which enhances their analytical thinking skills and understanding of the processes occurring in the world around them.

- ***The Manifestations of Improvement in the Prediction Skill***

The improvement in prediction skills demonstrated children's ability to use available information to predict future outcomes, which was enhanced through the narrative methods in digital stories that promote critical thinking. In this context, 85.7% of the children's responses indicated that the improvement in acquiring scientific prediction skills in digital story-based learning environments enabled them to connect the information they received from stories with their life experiences, thereby strengthening their ability to predict what might happen based on the scientific knowledge acquired. For example, one quote mentioned:

"In the story, they said that water boils when heated, and when we tried it at home, the water actually started to boil."

This shows how children could connect what they learned from the digital story with real-life experiences, and thus, they were able to predict the boiling of water when exposed to heat. This suggests that digital stories not only present scientific content but also stimulate children to engage in critical thinking and apply knowledge practically in daily life.

Moreover, an aspect of improvement in learning the prediction skill in digital story-based environments was the enhancement of critical thinking skills in children, encouraging them to interact with the events and their sequence in the digital story and determine how these events could lead to specific outcomes. As stated in one response:

"In the story, the water in the container started to boil when we put fire on it. I knew it would evaporate if I kept it longer."

This reflects the children's improved understanding of natural phenomena based on the story, where they connect concepts they have learned, like water temperature, with predicting natural outcomes like evaporation. This interaction demonstrates the children's ability to use scientific knowledge to logically predict outcomes.

Also, the increase in the skills for the purpose of prediction in digital story environments is presented through the opportunity for children to practice prediction interactively in order to improve their understanding of scientific processes. Prediction is not only theoretical knowledge of when something will happen, but it is also a practice of joining information together to understand how different factors result in particular outcomes. As one of the quotes has:

"When we saw in the story how water boiled, we expected it would evaporate if we kept it on the fire longer, and that's exactly what happened!"

From the interactions, it was evident that children were able to use the digital story to test their predictions and come up with answers that they could back up in the real world. This interaction with digital stories improves children's understanding of cause and effect, leading them to make more accurate and realistic predictions.

The interview analysis also revealed that one of the key aspects of improvement in the acquisition of prediction skills in stories, digital story-based sequential learning content environments, is visual presentation, which helps develop children's imagination and logical thinking ability. in digital sequences, which in turn enhances children's ability to predict outcomes. For example, one quote stated that "Through digital stories I can imagine what will happen next in the story, and this develops my critical thinking to predict the outcomes of events in the story".

"I expected the water would evaporate when it was hot, and that's exactly what happened when we tried it."

From the experiment, children were able to use their prior knowledge from the story to predict what would happen in the future. From the interview analysis, the most important ability growth of children in digital story-based learning environments is their ability to connect scientific knowledge to real-life practical applications. This also strengthens their prediction skills, which is not just passively listening to a story but also interacting with the story and its outcomes. As demonstrated in the response:

"In the story, there was boiling water, and I expected that if I kept it longer, it would boil more and might even evaporate."

Through these stories, it can be seen that children are better at generating consequences based on the information they have learned, which shows that digital story environments are effective in developing the prediction skills of children.

5- Discussion

5-1- Discussion of the First Research Question

The findings of the first question show that digital storytelling-based learning environments have a positive effect on increasing children's primary science process skills, such as observation, classification, and prediction. The experimental group showed higher improvements in these skills than the control group, which indicates that these environments have a great effect on stimulating critical thinking and cognitive engagement with scientific phenomena. It is vital to focus on how these interactive environments improve children's understanding of scientific concepts and connect them to everyday life.

The use of digital storytelling-based learning environments has improved children's scientific skills, such as classification and prediction, to some extent because digital storytelling offers a hands-on way of learning that requires children to think critically and make sound conclusions. Digital storytelling is not only a way of presenting information but also encompasses the forms of presentation (text, still images, and multimedia) that make the learning process more creative and effective. These media assist children to learn and understand complex scientific concepts by relating abstract ideas to their everyday lives through visual aids like animations of scientific processes and phenomena such as the water cycle or temperature change. This interaction assists children in learning causal relationships in a better way. Furthermore, digital storytelling environments allow children to play an active role in the learning process, which enhances critical thinking and the forming of hypotheses and testing of these hypotheses against the real outcomes, which in turn improves observation and classification skills. This interactivity also makes the children sit back and think about the content and ask questions and thus enables the child to relate the information with other areas of knowledge. Therefore, digital storytelling offers a motivating environment for children to continue to develop their knowledge and understanding of scientific concepts in a more systematic and logical manner.

This study's findings are similar to those of previous research [25-27] that has found that combining text with animations boosts learning and retention of scientific concepts for learners. Digital storytelling, which combines both visual and textual elements, allows children to understand better and more accurately understand natural phenomena than from texts only. It makes them focus on the critical points of the story, and it helps in the cognitive processing and retention of scientific concepts. These results support the use of digital storytelling to enhance children's scientific knowledge, as it provides a more engaging and interactive learning method than traditional techniques. Further research might also investigate how digital storytelling compares to other forms of interactive learning, such as augmented reality or gaming, in terms of their effectiveness in promoting scientific thinking and cognitive development.

The outcomes showed that children in the experimental group were better at describing the natural phenomena than children in the control group. This is because digital storytelling is sequential and visual, which enables children to have their eyes on the details and be able to identify some changes as they learn. Interacting with the digital environment, however, improves children's capacity to perceive phenomena in a more holistic manner. Based on the study by Fraihat et al. [11], interaction with digital stories may also help children to connect new knowledge to their everyday lives and, therefore, improve their understanding of scientific phenomena.

Moreover, the findings showed that children in the experimental group performed better in categorizing and sorting information than the control group. This improvement may be due to the sequential nature of digital storytelling, through which children are forced to arrange events in a logical order, which enhances their logical thinking. Logical sorting of information improves its understanding, e.g., it decreases the cognitive load and enhances children's abilities to sort and arrange information. minimizes This cognitive load is in line with doing so; cognitive load increases the theory that learners' ability states that process organizing information properly in a sequential manner [13, 17, 28, 29].

The predictions skill test results showed that children in the experimental group were better at hiring their future based on knowledge learned from digital storytelling than the children in the control group. This improvement suggests that children were able to see how to link information to potential outcomes in a critical thinking manner. Digital storytelling is not just a way of presenting knowledge in a static form; instead, it challenges the children to think through how different factors might affect natural phenomena and thus, in turn, help them to predict the outcomes based on their learning.

The results show that digital storytelling-based learning environments are effective in increasing children's primary science process skills by providing an interactive and stimulating environment that links theoretical knowledge with practical application. This is important as children develop their critical thinking and essential scientific skills.

5-2- Discussion of Results for Question Two

The study outcomes show that the children who participated in this research made great progress in their ability to observe when they used digital story-based learning environments. The children said they could better observe things, such as the melting of snow or the state of water in the cold. This improvement is the sign of a marked enhancement in their sensory skills. Such results can be attributed to the engaging and interactive nature of digital media, which fosters deeper involvement in learning processes and encourages children to notice finer details that are often not noticed in traditional learning environments.

These results may also be explained by the effects of interactive media on the brain from a neurological and psychological perspective. Stimulation of neural activity in areas of the brain associated with sensory learning, focus, and attention results from interacting with digital stories. This means that multisensory interactive activities enable children to process information more effectively, as found by researchers [8, 9, 10, 14, 30], who showed that digital technologies improve children’s attentional capacity and sensory responsiveness to the point where they are motivated to notice subtle changes in their environment.

The study also found that digital story-based learning environments significantly enhance children’s classification skills in a way that reflects them as being more organized in the way they arrange their knowledge and understand scientific processes better. This shows that children were able to arrange items in a way that they were able to categorize elements depending on their properties in order to better understand scientific concepts. This is due to the fact that digital stories are interactive and engaging and thus offer simple and easy-to-understand visuals of the information being given. Fraihat et al. [11] pointed out that digital media assists children in understanding abstract scientific concepts by representing them as concrete and visible images so as to help them in classification.

These results also match the idea that digital story-based environments offer children sensory and experiential interactions with concepts. For instance, after being exposed to content on how to classify water as either freshwater or saltwater based on their properties, children learn in a holistic manner how such classifications are to be applied in real life. This connection aids the children in ordering acquired knowledge from digital stories to everyday situations, making these skills more practical and effective. Similarly, Fraihat et al. [11] found that digital stories enabled children to incorporate scientific concepts into tangible scenarios, thus improving their classification skills.

The findings also showed that digital stories do not only teach the children how to arrange things in order of their characteristics but also improve the children's comprehension of the scientific criteria and the principles that govern the classification. For example, children learned how to classify water based on health parameters, for instance, desalinating saltwater for drinking. Such learning enhances scientific knowledge and awareness of environmental and health issues. Bani-Irshid et al. [16] have found that incorporating scientific concepts into daily-life contexts, such as categorization by health or environmental criteria, improves the generalization of children’s knowledge.

The results of this study show that children’s classification skills are improved significantly, and this finds out that digital story-based learning environments are efficient in breaking down scientific concepts into simple forms and also help in developing critical thinking skills. These environments offer content in a clear and sequential form, which allows children to progress from the more superficial to a deeper and more systematic way of thinking in science. This is consistent with the findings of several previous studies, such as those of Girmen et al. [31], Dewi et al. [32], Duveskog et al. [13], and Göçen Kabaran & Aldan Karademir [14]. These studies found that digital storytelling improves the ability of children to arrange and categorize information in a logical order, and there is a significant increase in the cognitive skills.

In addition to that, digital stories assist children in developing their sensory abilities through being able to observe physical properties and differentiate between scientific concepts. Through interactive narratives, children are able to link their classifications to real-life scientific standards, which assist them in seeing how connections are made between different elements. For instance, digital stories are designed such that children are presented with scenarios where they have to arrange different objects or situations in a specific order or categorize them in particular ways based on their properties. This therefore encourages children to think logically and make reasonable categorizations of concepts.

When comparing the findings of this study to earlier research, the results support the conclusion that digital storytelling is an effective tool for improving classification skills. Dewi et al. [32] and Duveskog et al. [13] both describe how digital storytelling helps children understand the relationships between scientific concepts and how they can properly categorize them. Similarly, Girmen et al. [31] and Göçen Kabaran & Aldan Karademir [14] both found that digital stories not only improve cognitive skills but also sensory and perceptual skills, as they provide children with an interactive way of engaging with scientific concepts.

The study also discovered a positive change in children's prediction skills in digital story-based learning environments, which these settings are capable of stimulating in children to connect digital stories with real life. Therefore, this improvement enables children to predict the future based on scientific concepts. The development in the prediction skills can be attributed to the narrative features of digital stories, which promote the logical and rational use of information and, consequently, allow children to make their predictions based on the scientific knowledge they have accumulated. From this study, it is concluded that prediction is a fundamental scientific skill that supports deep learning and the development of scientific thinking in children. As constructivist theory suggests, children enhance their predictive abilities through integrating sensory experiences with their knowledge of the environment [11, 17, 28]. These results align with the principles of digital storytelling-based learning environments where children can apply their scientific knowledge within interactive contexts and sequential events and where they can better anticipate outcomes based on causal relationships. When comparing these findings with previous studies, many have confirmed the positive effect of digital storytelling on children's prediction skills. For example, Bilen et al. [1], Bratitsis & Ziannas [2], and Fraihat et al. [11] pointed out that interacting with digital stories enables children to test their predictions in real life, for instance, when it comes to temperature changes and how they affect materials like water. In these studies, children were provided the opportunity to test their predictions, see the outcomes in real time, and discuss the outcomes to enhance their understanding of scientific phenomena.

These findings are extended by this study in the context of digital stories, which reinforces the importance of prediction. It shows how such interactive environments do contribute to a deeper understanding of scientific principles for children through the simulation of events and causal relationships. This study also contributes to the knowledge base on how children benefit from digital storytelling in order to enhance critical and causal thinking skills.

The present study and previous research differ in their findings as to how much benefit is derived from digital learning environments in terms of improving prediction skills and scientific thinking. This is thus a basis on which future research could build upon, since the present study finds that digital storytelling is an effective way of enhancing children's scientific skills. The results of this study suggest that the use of digital storytelling is an effective method of improving children's scientific skills, and thus it can be recommended as a practice that can be used in the future. Other future studies could then investigate other forms of interactive technologies, such as augmented reality or gamification, to see how these are able to improve prediction skills and scientific thinking in children across different learning environments.

6- Conclusion

The results of the study demonstrate that learning environments based on digital storytelling are an effective tool for developing children's science process skills, such as observation, classification, and prediction. Digital stories that integrate multimedia elements like text and animated images provide an interactive learning experience that enhances both emotional and cognitive engagement. Digital stories also allow children to present their science ideas in a more comprehensive form by linking the content to visually represented life experiences, which aids in the better retention of these concepts. These environments also support critical and analytical thinking skills, in which children engage with scientific phenomena through interaction with fictional characters and live scenes, and with activity improve their ability to classify data and predict outcomes from information provided.

Based on these benefits, it is recommended to integrate digital storytelling-based learning environments into early childhood curricula. Teachers and educational developers should collaborate to design innovative learning tools that combine digital stories with interactive activities to stimulate scientific thinking skills. Continuous training for teachers on how to use these tools effectively is also necessary to encourage active learning and critical thinking. It is also recommended to provide digital resources in rural areas and regions far from cities and the capital, Amman, to make sure that all children benefit from these innovative educational tools.

6-1- Limitations and Future Research Directions

A small sample size was a restriction of this study, and it was only on children from public schools in northern Jordan. This limitation of the generalizability of the findings to other regions or populations, especially to urban settings or other geographic areas with different educational and technological infrastructures, is not withstanding. In future studies it would be useful to include areas with diverse socioeconomic backgrounds to help to establish how widely applicable the results of this research are and how regional and demographic factors might affect the effectiveness of digital storytelling in helping children to develop science process skills.

The focus was only on basic science process skills like observation, classification, and prediction, and other potentially significant skills were not addressed. This research could be extended into a broader range of cognitive and social skills, including critical thinking, creativity, and collaboration within digital storytelling environments. In addition, using more comprehensive assessment tools such as classroom observations and teacher evaluations could provide a better insight into how children engage with and gain benefits from learning through digital storytelling.

This research does not consider children's cultural and educational backgrounds, though these may have a potential impact on the effectiveness of digital storytelling-based learning environments. Future studies could also look into how children's cultural contexts and prior educational experiences shape their engagement with digital storytelling and the development of their science process skills, respectively. Furthermore, a long-term follow-up study could investigate the sustained effects of digital storytelling-based learning environments on children's skills over a longer period.

The study did not control the length of stories told through digital storytelling, which could have been quite different from one story to another and may have consequences for engagement and learning. This would help future research in this area, which could benefit from a more rigorous experimental design that looks at story length and other variables that might affect student responses. First of all, this study did not include comparison with other interactive technologies, such as augmented reality or gamification. Since these technologies are now widely used in educational settings, future research should compare them with digital storytelling in terms of their effectiveness in achieving various learning outcomes. This comparative research may contribute to the identification of the most efficient pedagogical approaches to develop critical thinking and scientific reasoning in children.

Future studies could also investigate the results of combining digital storytelling with other forms of interactive learning tools, such as games and educational apps, in order to enhance children's interest in science as well as their scientific thinking. Therefore, educators can create more engaging and multifaceted learning environments using a variety of learning resources, including digital storytelling, to meet the needs of different learning styles and abilities.

7- Declarations

7-1- Author Contributions

Conceptualization, A.A.A., R.M.A., and O.M.A.; methodology, A.A.A., R.M.A., and O.M.A.; validation A.A.A., R.M.A., O.M.A., and N.A.I.; data collection and analysis, A.A.A., R.M.A., O.M.A., and N.A.I.; writing—original draft preparation, A.A.A. and R.M.A.; writing—review and editing, A.A.A.; supervision, A.A.A.; project administration, A.A.A. All authors have read and approved the final version of the manuscript.

7-2- Data Availability Statement

The data presented in this study are available on request from the corresponding author.

7-3- Funding and Acknowledgements

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7-4- Institutional Review Board Statement

This study was reviewed and approved by the Deanship of Scientific Research at King Faisal University with the approval number: KFU-REC-2024Feb-EA000583, dated 19/2/2024.

7-5- Informed Consent Statement

Informed consent was obtained from all participants included in the study.

7-6- Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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Appendix I: Interview Questions

Dear Student,

Welcome to this interview! The purpose of this interview is to understand how the use of digital storytelling has helped you learn science and develop your skills in this area. We will ask you some questions to discover how digital storytelling has helped you understand lessons better. We would love to hear your experience and thoughts on how you benefited from this type of learning.

Part 1: Basic Information

- **Gender:** ☐ Male ☐ Female
- **Academic Level of the Student:**

☐ Excellent (90% or above)
☐ Very Good (80% - 89%)
☐ Good (70% and 79%)
☐ Average (60%- 69%)
☐ Weak (below 60%)

Part 2: Interview Questions[*]

Were you able to learn science topics after using digital storytelling? Can you tell me about a situation where this happened?

- Follow-up: How did you feel when you learned science using digital storytelling? Did you find this form of learning easier or more enjoyable?

  ☐ Easier

  ☐ More enjoyable

  ☐ I don't know

- Follow-up: Do you remember a specific lesson that was enjoyable because of digital storytelling? How did this affect your understanding of the lesson?

  ☐ Yes

  ☐ No

- If yes, please explain how it helped you understand the topic more deeply. Was there something in the digital stories that helped you connect the information to real-life experiences?

Do you think digital storytelling helped you learn the topic "Water in Our Lives" better? Did you notice any improvement in your understanding of this topic? What things did you find clearer?

- Follow-up: How did you feel when you learned about water and its uses in daily life through digital storytelling? Was this method better than traditional methods?

  ☐ Yes

  ☐ No

  ☐ I don't know

- Follow-up: Was there something in the topic "Water in Our Lives" that became clearer to you because of digital storytelling? For example, did you understand how we use water in our daily lives or the importance of conserving it?

  ☐ Yes

  ☐ No

- If yes, please explain which part of the topic became clearer to you.

[*] The interview consisted of three major questions, each of which includes a number of sub-questions. These sub-questions consider as probing questions that aid the interviewer delve deeper into understanding the studied phenomenon.

- Follow-up: Did digital storytelling help you remember the information better? How did this affect your understanding of the topic?

  ☐ Yes

  ☐ No

  ☐ I don't know

- If yes, how did this affect your ability to use this information in your daily life?

Can you give me an example of how you applied what you had learned from digital storytelling in your daily life?

- Follow-up: Did you learn something from the digital stories that you could use in school or at home? For example, can you now talk about the importance of conserving water or how to save it?

  ☐ Yes

  ☐ No

- If yes, how did this impact your daily behavior? Did you try to apply certain tips you learned from the digital storytelling?

- Follow-up: Did you feel that digital storytelling helped you understand something in your daily life, like how to conserve water or use it more efficiently?

  ☐ Yes

  ☐ No

  ☐ I don't know

- If yes, do you feel that this method of learning is more effective than traditional methods at school? Why?

Thank you for participating in this interview. Your answers help us better understand how digital storytelling impacts learning science and how we can improve learning methods for children like you in the future. We appreciate your time and effort in answering these questions, and we hope you enjoyed learning through digital storytelling.

Best regards,

Student's Code No……