

Student Teachers' Reflections on the Use of Drama in Education to Motivate Young Children's Science Play

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Abstract

This study explored student teachers' reflections on the use of drama in education (DIE) to motivate young children's science play during a course, "creative science activity design for young children," at a teacher development program in southern Taiwan. The participants comprised 21 student teachers who took the course taught by both researchers. Participants designed science play activities using DIE strategies and implemented the a for a group of preschool children. The data sources employed in this study were observations, interviews, and collected documents. The data were analyzed qualitatively. The findings revealed that the DIE strategies adopted by the student teachers included warm-up, improvisation, and story roleplaying. The results indicated that the student-teachers considered drama to have aroused the children's motivation to engage in science play. Advantages and challenges relating to the application of DIE strategies in science play were presented. Suggestions for future implementation of and research on DIE strategies in science play are presented herein.

Keywords: Early science education, teacher development, children's science play, drama in education (DIE)

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Introduction

Children between the ages of 3 and 6 years are curious about their environment and the natural phenomena that they observe. Therefore, young children require science education to learn and generate ideas about the environment in which they live (Özbey & Alisinanoğlu, 2008). Early science education helps children develop a positive attitude toward science early on (Campbell et al., 2021). Although most science education studies have focused on the cognitive aspects of science learning, educators tend to underscore the key role of affective factors, including interests, motivation, and attitudes (Alsop & Watts, 2003). Play is an effective method for stimulating children's interest in science learning (Campbell et al., 2021). "Science play" in this study is defined as children's play activities guided by adults (e.g., asking questions and joint play) for encouraging the children to engage in the science exploration processes of prediction, observation, practice, and verification (Weisberg et al., 2016). Motivating young children to engage in science play is challenging. Preschool children's interest in scientific inquiry is contextually dependent (Russell & McGuigan, 2016). Proponents of drama in education (DIE) view drama as a teaching medium that allows students to participate in and demonstrate learning in a nonthreatening environment (Poston-Anderson, 2008). DIE has been used to stimulate children's interest in learning many subjects, including mathematics and science (Isyar & Akay, 2017).

Therefore, children's motivation to engage in science play can likely be inspired using DIE strategies. Relevant studies have confirmed this inference. For example, Abed (2016) suggested that the appropriate application of DIE can make science learning more contextual and engaging for children. Drama creates a virtual space in which participants can conduct experiments to explore various problems, simulate various feasible solutions, and reflect on strategies for solutions (Braund, 2015; McLennan, 2008). The Dana Foundation (2008) suggested that participating in drama activities has a considerable effect on children's brain development, learning motivation, language development, and learning ability. Lin (2005, 2017) indicated that drama assists preschool children in developing imitative skills, memory perception, attention, and concentration and that these abilities are crucial for exploring science. However, few studies have explored how student preschool teachers apply DIE in science play or their views on the use of DIE in science play. The current study filled this

research gap by exploring student preschool teachers' reflections on the use of DIE in children's science play. The research questions were as follows:

1. What are the methods for incorporating DIE into science play for young children?
2. What are preschool student teachers' views on the application of DIE strategies in children's science play?

Literature Review

Application of DIE strategies

In early childhood education, researchers consider drama as an effective method for guiding learning. Children learn to solve problems, develop movement concepts, and cultivate sensory creativity by participating in drama activities (Lin, 2017). In this context, learners must perceive things from the perspective of others (i.e., dramatic roles), think of themselves as others, and make judgments in accordance with the knowledge and experience of various characters. This experience can help learners experience the feelings and emotions of others (Lin, 2017). DIE strategies can be employed in teaching through various methods, including extraordinary performances and empirical strategies (Ødegaard, 2003).

DIE strategies often involve improvisation, role playing, imitation, and drama games for achieving teaching goals (Lin, 2017). The type of drama used in education is not a stage performance but rather a teaching strategy and medium through which students can learn. Therefore, DIE strategies are characterized by semi-structured improvisation and are not based on performance.

DIE strategies can be combined with learning activities in various fields such as language learning, natural sciences, and art. Drama can provide a flexible and lively teaching environment in which teachers can guide learners into scenarios of dramatic imagination. In such scenarios, teachers can present various problems, guiding students to enter role-playing situations to discuss and determine solutions through improvisation (Lin, 2017). Participants can use their bodies and voices to explain the situations or problems encountered by their characters and subsequently engage in problem-solving processes. Different from traditional

teaching methods, DIE strategies are advantageous mainly because they enable learners to freely use their imagination, express thoughts, experiment, and learn through improvisation, role playing, and imitation games in the virtual context of drama (Lin, 2017).

In addition, during dramatic performances, when a learner acts as a problem solver, he or she must recall, reflect on, and unify himself or herself in the context of real-life people, times, places, events, and objects. Actors must use symbolic actions, props, and language to recreate and express ideas to demonstrate their understanding of and solutions for situational problems. In addition, teachers can use DIE to evaluate learners' understanding of problems and solution strategies (Arnold & Millar, 1996).

Drama in science education

In general, science is considered to emphasize logical thinking and dialectics, whereas drama is considered to focus on emotional and creative performance. The two appear to be highly distinct, but practicing drama in the context of science education is common in Europe and the United States. In fact, theater companies in Northern Europe promote popular science activities through drama (Skjoldager-Nielsen & Skjoldager-Nielsen, 2018). In the current study, relevant research regarding the combination of science and drama is summarized as follows.

Drama constructs the context of science problems

McCaslin (2006) suggested that DIE can assist students with in-depth exploration and understanding of various subjects. In DIE, learners are not the audience but rather are invited to solve the problem. For example, a teacher may design a drama in which the characters attempt to construct a flying vehicle but often fail. The characters can then ask students to identify possible problems and provide suggestions. Therefore, DIE strategies can feasibly be used in science play to create and construct problem scenarios for encouraging children to think of solutions. For example, a teacher may design a drama involving a problem situation wherein a group of animals wishes to reach an island by crossing a river. The children can discuss solutions for helping the animals cross the river, such as building a bridge. Finally, the children can present their problem-solving methods in groups by using drama. This type

of design makes the problem-solving process more contextual and interesting and attracts children's interest and desire to actively explore and participate in science play.

Scientist stories can be incorporated into drama

Another method for incorporating DIE strategies in science education involves teachers implementing historical stories about scientists into dramas. In such dramas, students play the roles of scientists, mimicking the thinking processes involved in scientific discoveries and practicing scientific experiments (Duveen & Solomon, 1994; Ødegaard, 2003). For example, Budzinsky (1995) asked students to prepare a short drama about the life and professional achievements of various scientists. To produce an accurate performance, the students had to actively inquire about specific information and participate in the editing and directing. Consequently, the students learned about the contributions of the scientists they were imitating during the performance. Through drama, students can effectively learn about scientific concepts and experimental processes. Solomon (2002) suggested that a specially designed storyline enables school children to understand the nature of science and discuss scientific issues, and they can resonate emotionally with the storyline.

Method

Our study was pragmatic and employed qualitative research methods (Creswell, 2014) to elucidate the potential applications of DIE strategies in children's science play. Because our investigation of DIE use had time (18 weeks) and space (one classroom) limitations, it can also be considered a case study (Yin, 2017). We examined how student teachers used DIE strategies to stimulate children's interest in science play during an 18-week course at a teacher development program in southern Taiwan. During the course, DIE strategies designed to encourage science play were presented to the student teachers. The theoretical basis for this study is that DIE strategies can be used to construct problem scenarios in science play. In addition, teachers can mimic the thought processes of scientists involved in scientific discoveries to develop children's problem-solving abilities. After being motivated to engage in science play by DIE strategies, children assume the leading role in their process of

scientific inquiry. Adults can select the appropriate time for intervention by raising questions or guiding exploration (Gerde et al., 2013).

This study was approved by the Institutional Review Board (IRB). Informed consent was obtained from all participants; this involved informing the participants of their rights; the objectives, procedures, and expected duration of the study; potential risks; benefits of participation; and the confidentiality of personal identifiable data and demographic data. Participation was entirely voluntary.

Participants

The current study was conducted in a creative science play design course taught by the two authors of the study. The research site was at a teacher development program in southern Taiwan. As the researchers, we assumed the roles of instructors, resource providers, guiding question-askers, and course supporters. The course was an elective for senior students in early childhood education. Twenty-one student teachers (4 men and 17 women aged 21–22 years) participated in the study. Most of the participants had teaching practicum experience and had taken courses in early childhood drama, children's theater, or performing arts. Therefore, most of the student teachers had preliminary experience in curriculum development and activity design for young children. The course intended to rely on the student teachers' knowledge and experience in preschool curriculum design and drama teaching.

Course content and teaching methods

The course was held over 18 weeks. The first 5 weeks addressed relevant science education and DIE theory and involved discussions, workshops, and practice. The remaining weeks involved the design and implementation of the science play activities, with repeated blocks of 1 week of peer review followed by 1 week of practice with children, in rotation. The science topics included water, air and temperature, force and movement, sound, light and shadow, and chemical reactions, each of which was a design theme. The science play activities were designed by the student-teachers in groups (each with 4 or 5 members). Each

group designed four science play activities and integrated one DIE strategy in accordance with the theme. Science topics were provided only as suggestions; the student-teachers were allowed to freely choose from various science topics as long as any topic was not repeated.

During the design process, the student teachers regularly talked with the researchers about the difficulties they encountered while designing the play activities. In addition, DIE experts were invited to conduct a collaborative teaching program at the beginning of each class. The DIE experts had taught drama-related courses in early childhood education for at least several years and had experience in assisting student teachers in producing science dramas. At the beginning of the semester, the DIE experts administered a 6-hour workshop for the student teachers on using DIE strategies in science education to facilitate the design of a course. After the student teachers designed the science play activities, they invited their peers to apply them in practice. Afterward, the implementation group provided the design group with feedback on the problems they encountered. The DIE experts were also invited to observe the designed course and provide suggestions. After the student teachers implemented corrections in accordance with the feedback, the researchers invited the children into the classroom to participate in the revised science play activities.

We invited preschool students aged 4–6 years, to the classroom to participate in science play activities every other week to test the student teachers' designed science play activities. The children were recruited from preschools with which we have developed a close cooperative relationship during practicum courses. At each practice session, one class of 20–30 preschoolers participated in the science play activities; after five sessions, 135 children had participated in the science play activities.

Data collection

Observation

Course observation started at the beginning of the semester, and courses were observed once a week for 3 hours each time. The main aspects that were observed included methods for incorporating DIE strategies into science play, problems encountered, and the overall effects. After obtaining consent from the participants, the entire course was recorded every week. After class, the observation data were transcribed into anecdotal records. The

researchers evaluated the anecdotal records after each class and subsequently compared and analyzed the data. During science play implementation, the reactions of the children and preschool teachers who participated were recorded and compared. The researchers also observed the DIE experts' discussion and feedback during the workshops.

Interviews

The 21 student-teachers who participated in the course were interviewed. The student-teachers received both formal and informal interviews. The formal interviews were conducted in a focus group format. The student-teachers were interviewed mid-term and at the end of the semester. The semi-structured interview of each group lasted 30–40 minutes. The interview questions were (1) “How do you make a plan of integrating DIE strategies into science play design?”; (2) “How do you implement DIE strategies during science play activities?”; (3) “What difficulties did you encounter during the design process?”; and (4) “How would you evaluate the effectiveness of DIE strategies in the design of science play activities?”. A final interview was conducted for summarization and assessment to determine the student teachers' overall views on using DIE strategies in science play. In addition, the student-teachers conducted a self-assessment. Because the teacher/researcher was a figure of authority in the classroom, the interviews were conducted by a professionally trained research assistant. The entire process was conducted and recorded anonymously.

Document collection

All relevant documents used in the course were collected for analysis and included lesson plans, children's learning sheets, and reflections on teaching by the researchers and student teachers. The student teachers developed 24 lesson plans that incorporated DIE strategies into science play activities and completed reflection papers immediately after each investigation session. These data were collected and classified for analysis.

Data analysis

Data were analyzed mainly on the basis of the research questions. The data sources (i.e., observation records, interview records, group discussions, and documents) were stored in the

ATLAS.ti database. The data were recorded according to [data collection method-data source-date]. Open coding was performed first, and keywords that consistently appeared in the data were extracted into concept codes (e.g., DIE strategies, challenges, and effectiveness). Next, critical concepts mentioned in the literature were added as the coding basis (e.g., role play and inductive questioning). All codes were then reviewed and categorized into topics, and the topic concepts and categories were extracted and abstracted, respectively, for topic analysis. Finally, the relevant literature was reviewed and compared with the data to establish explanations and theories.

The data triangulation method (Yin, 2017) was used to improve the reliability of the analysis and to support the interpretation and commentary of the research findings. Because this study was conducted by two researchers, both researchers taught, collected, and analyzed data collaboratively. In addition, the researchers reflected on possible prejudices and contradictions to improve the reliability of the analysis.

Result

Methods for incorporating DIE strategies into science play

Use of story roleplaying to create problem scenarios

Some of the groups of student teachers used the story roleplaying method to create problem scenarios in science play activities. For example, the “Light and Shadow” group used the story roleplaying strategy to create a short play called *The Light-Speed Man* to pique children's interest in the nature of light and shadow and help them understand the main tasks of each of the four science play activities. The content of the play is as follows:

A: It's light-speed man! Light-speed man, what are you up to?

B: I have some difficulties and I want to find someone to help. Can you help me?

A: Yes, light-speed man; what can we do for you?

B: I encountered four difficulties—four difficulties!

A: What difficulties are they?

B: My friend was taken away by the bad guy. When I went to find him, I had to go through

a maze. The maze requires a password. I found the password, but it was accidentally covered by a splash of water. Will you [the children] help me find the password? Children, look at the bright lights over there [points to the first task station]. You can help me find the password there.

A: After we find the password, you can enter the maze! What is the second difficulty?

B: I have heard that there are many roads in the maze. I want to ask the children to help me find the right way so that I can get out of the maze. Kids, look over there [points to the second task station]. That is the maze! Please help me find a way out of the maze!

A: Isn't there a third difficulty?

B: Yes. There are many doors at the end of the maze. I don't know which is the right one. Kids, can you help me find the right door so that I can walk through [points to the third task station]?

A: No problem; and the fourth difficulty is...?

B: The last one is...my friend was taken away by the bad guy several days ago. He must be very hungry, so I want to ask someone to help him find food [points to the fourth task station]. After eating the food, my friend will have the strength to go home with me (observation-drama-20191216).

To motivate children to participate in and understand the content of each science play activity, the student-teachers created a drama and gave the children problems to solve. The “password” task was intended to direct the children to mix different colors of cellophane to explore the characteristics of the sun’s white light. White light can be converted into colored light by passing it through sheets of cellophane of various colors. The children could also use colored light projections to discover hidden colored numbers in the embedded dots (the password). The “out of the maze” task was intended to direct the children to use a flashlight to project different objects (e.g., cellophane, a block, an iron basin, a magnifying glass, glass, plastic, water, a mirror, aluminum foil, and plastic wrap) to determine which objects would reflect light. The children could then use the objects to project light onto the maze path, illuminating the path to the maze’s exit. The “penetration door” task was intended to direct the children to identify which objects could and could not be penetrated by light. The design team prepared newspapers, tissue paper, cellophane, water, petals, corrugated paper, CDs,

dead leaves, cardboard, and cups filled with water and paint for this station. The children were encouraged to predict and verify which object could transmit light and help “light-speed man” penetrate the objects. The “bird finding food” task was intended to direct the children to use the shadow created by the distance between the object and the light source to help the bird’s shadow “eat” the food, which was pasted on the wall.

Use of warm-up and improvisation to present science tasks

Improvisation is an unscripted, unrehearsed, spontaneous set of actions in response to minimal direction from a leader (Emunah, 2019). Some groups of student teachers used warm-up and improvisation to present science tasks. For example, the “Air” group performed a skit in which Teacher A sent a polyester (PET) bottle to Teacher B:

A: I have a special gift for you. The gift is inside the PET bottle.

B: But nothing is inside the PET bottle.

A: There is one thing inside the bottle. Children! Do you see the thing inside the bottle?

(observation-drama-20191114)

The student teacher asked the children which of them thought that “something is inside the bottle” or that “nothing is inside the bottle” and encouraged them to individually share their opinions. This improvisation strategy piqued the children’s interest in exploring the topic of air. After that, the student teachers introduced the four science play activities related to the air theme.

In addition to presenting science tasks, the student teachers highlighted the materials and safety rules applicable in each of the science tasks by implementing DIE strategies. For example, in the “light-speed man” play, the student-teacher said “*light-speed man told me that when he went to solve problem, he would use a flashlight and a laser pointer. Do you know what that is?*” (observation-drama-20191216). The student-teachers used storytelling to incorporate flashlights and laser pointers and remind children how to use them safely; two teachers stated, “*Because the drama situation was interesting, the children were much focused on listening to the safety rules and the introduction of each science play*” (reflection-teacher A-20191216) and “Dramas were used to remind children of safety issues. Drama is much more effective than the teacher’s oral description” (reflection-teacher B-20191216).

The DIE strategies used in the science play activities mainly comprised story roleplaying, warm-up, and improvisation. The details of the DIE strategies employed by the student teachers for each science play theme are presented in Table 1.

Table 1. *Design of DIE Strategies Applied in Children's Science Play Activities*

Group	DIE strategy	Science play activity
1 October 24 October 31	Warm-up Improvisation Use of DIE to present four science problems /tasks to children	<u>Topic: Water</u> 1. <i>Why Will It Not Fall?</i> Why does the plastic sheet on the mouth of the cup not fall when the cup is turned upside down? 2. <i>How Many Coins Can It Hold?</i> Exploration to determine how many coins of various materials can be placed on a sheet atop a cup filled with water. Subsequent exploration to determine the effect of placing coins at various positions (close to center vs. away from center). 3. <i>Magic Rainbow Water:</i> Exploration to determine how varying amounts of sugar can be mixed to create a rainbow gradient of liquid in a test tube. 4. <i>Water Climbs High:</i> Exploration to determine what types of cloth materials can make water climb higher.
2 November 7. November 14	Warm-up Improvisation Use of DIE to present science problems/tasks to children	<u>Topic: Air</u> 1. <i>Hunter's Air Cannon:</i> Exploration of various box designs (e.g., with regard to the sizes of boxes and holes cut into them) to determine how many paper animals can be shot down. 2. <i>Air Hercules:</i> Exploration of how various materials of different designs can be used and how cups can be placed in water such that newspaper placed at the bottom of the cups does not get wet. 3. <i>Rotating Aircraft:</i> Exploration of how to design aircraft with various materials (e.g., straws of varying sizes and paper of varying thickness) such that it can fly far and rotate. 4. <i>Angry Boat:</i> Exploration of how various items (e.g., balloons, straws, and rubber bands) can be used to make a boat made out of a milk carton move faster in water.
3 December 5 December 12	Story roleplay Use of storytelling and roleplay to present science problems/tasks encountered during drama-based roleplay	<u>Topic: Force & Movement</u> 1. <i>Balancing It:</i> Exploration of how various materials (e.g., pencils, marbles, blocks, and erasers) can be used to balance a scale. Subsequent exploration of how the two arms of the scale can be adjusted to achieve balance. 2. <i>Spinning Top:</i> Exploration of how various materials can be used to make a top spin longer. Observation of

		variables that can influence a top's spinning behavior, as well as the implementation of top modifications.
		3. <i>Come-to-Play Slide</i> : Exploration of the effects of various slope configurations on the speed of a toy car. Children can design a "slide" that makes a toy car move faster.
4 December 19 December 26	Story roleplay Use of storytelling and roleplay to present science problems/tasks encountered during drama-based roleplay	<u>Topic: Light & Shadow</u> 1. <i>Magic Light Colors</i>: Exploration of how a flashlight and colorful glassine paper can be used to create assigned colors. 2. <i>Light Walks Through the Maze</i>: Exploration of how the light reflection effect can be utilized to "walk" and "move" through a maze to reach the goal. 3. <i>Penetration of Light</i>: Prediction and exploration of the types of items through which light can penetrate. 4. <i>Light Allows Pigeons to Grow Up</i>: Exploration of the distance between a light source and a shadow that allows a bird to eat.
5 January 2 January 9	Story roleplay Use of storytelling and roleplay to present science problems/tasks encountered during dram-based roleplay	<u>Topic: Chemical Change</u> 1. <i>QQ Bouncy Balls</i>: Exploration of how various ingredients (i.e., baking soda, glue, and contact liquid) can be mixed to create slime balls. 2. <i>The Secret of Balloons</i>: Exploration of the effect of adding varying amounts of baking soda and citric acid into a bottle filled with water. Observation of the changes that a balloon attached to the mouth of the bottle undergoes. 3. <i>Magic Fountain</i>: Exploration of the effects of adding various liquids (e.g., dishwashing liquid and hand soap) into milk dyed with various types of food coloring. 4. <i>Blowing Out the Candles</i>: Exploration of how various ingredients (i.e., baking powder, vinegar, salt, and sugar) can be mixed to produce gas to blow out a candle.

Techniques facilitating the use of DIE strategies in science play

Use animal or cartoon characters in key roles

The student-teachers mentioned that drama can stimulate children's interest, particularly when the protagonists are animals or cartoon characters: "*When children see the animals, they love them. Then, we can use the animal protagonist to ask questions to motivate the children to think about scientific problems. Our theme was mechanics, so we combined various animal characters when designing drama activities about mechanics*" (interview-

student feedback-20200109). A group of student-teachers believed that children were generally interested in animals, so they used animals as protagonists in the “force and movement” activity:

The little rabbit gets up in the morning. Mom said that she wants to clean the room. Hey! There is a box here. We should move the box so that we can clean the room. Get ready to move! One! Two! Three! Oh, why can't I move it? I must have eaten too little. I will try again! One, two, and three! I still can't move it; are there any kids who are willing to help? [The children raised their hands and wanted to help.] (observation- drama-20191212).

The student-teachers asked the children to help the rabbit carry the cardboard box to experience the feeling of force. Next, the student-teachers used the drama strategy “letter from the head of the animal village” to ask the children to help them solve the problem. The letter was as follows: “*Dear rabbits, I am the head of the animal village. I would like to invite everyone to help the animals in the village. After you enter the animal village, you will see squirrels who want to use the things on the table to build a tower to store food. Can you help them?*” (observation-drama-20191212). Through this drama scenario, the children were introduced to a science play activity in which they had to use cotton candy and spaghetti to build towers. The student-teachers used similar drama scenarios to ask the children to solve other science problems: “*The owl wants to maintain the balance of the tree so that the tree will not dangle while he sleeps; the tortoise wants to make a spinning top that will spin for a long time*” (observation-drama-20191212).

Present characters vividly

In the group discussion, the student-teachers suggested that the leading group should use body movements, voices, and expressions in their drama: “*When pointing to the owl's science task, students should imitate a real owl sleeping on an unbalanced branch. Then the rabbit comes to help it*” (observation-group discussion-20191205) and “*I think our body movement and voices should be in place to mirror the main animal characters in the drama scenario*” (observation-group discussion-20191205). One DIE expert suggested that the student-teachers should highlight the characteristics of the characters. For example, “*owls love to sleep, squirrels have to hoard food, and tortoises like to spin like a spinning top*”

(observation-group discussion-20191205). Doing so can make it easier for children to remember the crucial tasks of each science play activity. The expert emphasized that *"Integration is critical in DIE. You must integrate and establish relationships between roles and tasks so that children can remember what problems they need to solve by recalling the drama scenario"* (observation-group discussion-20191205).

Use various props to establish context

To make the science play activities consistent with the context of the story, the student-teachers designed each science play station to resemble the story's setting. In the group discussion, one student-teacher mentioned, *"Today this group is very creative. There are different animal pictures on each experimental object. It is very delicate. I think it will attract young children"* (observation-group discussion- 20191205). For example, in the *"balance"* science play station, the student-teacher mentioned, *"there is a fake owl standing in the middle of the unbalanced tree"* (observation-20191205). While observing the children participating in the activities, the researchers observed, *"it is easy for children to integrate into the drama scenario and strive to help the protagonist solve the problem"* (reflection-teacher B-20200109).

Views on the use of DIE in science play

Advantages of applying DIE strategies in science play

The researchers specifically revised the curriculum for incorporating DIE strategies into science play. The student-teachers expressed the following views regarding the advantages of using DIE strategies:

It [DIE] enables young children to understand concepts more deeply because they do not typically understand certain scientific concepts. I think they will be more interested in exploring science tasks introduced in dramas because they are presented in an interesting way...If the drama is conducted well, young children are impressed. Like in the "Light and Shadow" group—as long as the light is turned off, everyone knows that today's theme is light and shadow. The beginning is all dark, and each group turns on the light during the introduction. Children will pay attention to that station. This method is

superb...Children can clearly understand specific methods for helping the protagonist. Drama is very helpful for children. It can make abstract things concrete. Drama has this capability (interview-student feedback-20200109).

The student teachers reported that the DIE strategies left an impression on the children and motivated them to participate in science play. In addition, children were able to specifically learn about each science task. The researchers observed the children's reactions and asked the children for their opinions of the activities in which they had participated. Examples include *"I want to help the light-speed man find the passcode and exit the maze as soon as possible"* (observation-children's response-20191226) and *"I can help the animal keep its balance!"* (Observation-children's response-20191114). Children were very involved in the drama scenario and often acted as the protagonist in the drama (e.g., the light-speed man and owl).

Challenges of applying DIE strategies in science play

DIE storylines may not be adequately connected to science play. Several student-teachers experienced difficulty combining science play and DIE strategies: *"Drama can attract children, but I think there is still a little distance between drama and science play. It is difficult to try to link them"* (interview-student feedback-20200109). One student teacher further stated, *"If the storyline is not well connected [to the science], the children may be unclear about what to do"* (interview-student feedback-20200109). The student-teachers suggested that groups should not design the science play activities first and subsequently think about how to connect them with drama. Sometimes, a DIE storyline may be inadequately connected to the science play activities.

The student-teachers mentioned the following: *"The drama's design should perfectly integrate different science play tasks"* (interview-student feedback-20200109), and

The drama scenario can provide a clear context for thinking about and participating in the science play activities. For example, in the light-speed man drama, the children's task was to find a bird. So, first, they needed to find the password, walk through the maze, find the door, and finally find the bird. The drama was designed to connect the sequence of science play tasks (interview-student feedback-20200109).

Therefore, a short drama with clear context can help children understand and remember the content and sequence of science play tasks.

Children sometimes confuse drama with reality. The researchers noted that the children sometimes confused drama with reality. For example, students used different sugar ratios to modify the color gradient of water, and the colorful water was called a “beautiful drink” in the drama. However, the children could not drink the “beautiful drink” after going to the science station. The student-teachers constantly had to remind the children, “*This is a fake drink; you can't drink it*” (observation-20200110), confusing some of them. Therefore, student teachers must be careful when designing dramas using DIE strategies, particularly with respect to safety.

Integration of DIE in science play can confuse children. Several student-teachers felt that integrating four science play activities within one 10-minute drama may confuse the children: “*Too many things are introduced at once. The children may not remember which task is for which science station. Therefore, when the children go to the science station, the teacher leading the science station must explain it again*” (interview-student feedback-20200109). Furthermore, the sequence of children's participation in the science stations often did not follow the sequence in the storyline. The student-teachers stated, “*The order of the story is one, two, three, and four, which was designed according to the sequence of science stations. Nevertheless, the order of children's participation is random and based only on their interest*” (interview-student feedback-20200109). Because children could freely choose which stations they wanted to start and end with, the sequence of the storyline was not necessarily consistent with the implementation of science play activities.

DIE storyline constraints in science play. Some groups' drama designs were somewhat rigid because the storyline was constrained by the science play activities. The student-teachers gave an example: “*In the drama, the big bear wants to roll the ball. Then, the children have to find a way to build a ramp to help the big bear roll the ball faster. Why does the big bear roll the ball? How do you associate it with the whole story?*” (Interview-student feedback-20200109). Because most student-teachers designed the science play activities

before designing the drama, the drama could be somewhat bland. Sometimes, student-teachers simply added characters and plots specifically for the science play activities. Therefore, the two researchers reached a consensus: *“Perhaps future courses could allow student-teachers to develop two models for integrating drama with science play. One involves designing science plays before dramas; the other allows student-teachers to start with the story structure. Then, student-teachers can design science play activities to match the story’s structure.”* (Reflection-teacher A, B-20200117).

Limited effect of DIE drama on scientific exploration and understanding. Drama appeared to arouse motivation for understanding the content of science play activities but had no effect on scientific exploration and understanding. The student-teachers mentioned “The use of drama may create a more engaging experience for children, but it does not effectively help them to understand scientific concepts and phenomena” (interview-student feedback-20200109). The researchers also observed that children automatically adjusted to the real world when participating in and experiencing science play activities. Only when children discussed their scientific findings as a group would they return to the storyline’s tasks. Therefore, the student-teachers mentioned that *“instead of using imaginative drama scenarios, perhaps lifelike dramas would be more meaningful for young children in terms of science exploration”* (interview-student feedback-20200109). The researchers reflected, *“The drama scenario does not necessarily need to be a fairy tale or imaginative story. Drama can be designed according to children’s daily lives. Maybe, in the future, student-teachers can be encouraged to apply problems associated with children’s daily lives when designing a drama. Then, the science exploration will be more meaningful for the children”* (reflection-teacher A-20200109). Nevertheless, in the current study, drama is considered to have scaffolded the children’s interest in science play activities. Children’s understanding of scientific phenomena and principles still relies on hands-on exploration and guidance.

Discussion and Suggestions

The current study discovered that the student teachers were often able to apply DIE

strategies, including story roleplaying, warm-up, and improvisation, to construct science problem scenarios and present science tasks. These strategies are similar to the context-building actions described by Neelands and Goode (2015) in that drama is used to establish the context and atmosphere of science play. When children are engaged in a planned drama scene, they often act as the protagonist to solve the problems presented (Abed, 2016; Lin, 2017; Özbek, 2014). The results of the current study reveal that using animal or cartoon characters in key roles, presenting characters vividly, and using various props to establish context can facilitate the implementation of DIE strategies in science play. These findings are consistent with those of previous studies, which have reported that animal and cartoon characters are used in popular teaching tools in early childhood education (Morris, 2002; Wee, 2009; Yaman, 2010). In addition, a sign system combining vivid performances, gestures, props, and sounds in drama can be used to communicate significance to children (Özbek, 2014). Therefore, student teachers should present characters vividly and use diverse props to help children engage in the context of drama. Finally, this study determined that children's interest in exploring science through play can be successfully cultivated using DIE strategies. This finding is consistent with previous research reporting that learning is most effective when it is contextualized (Bowell & Heap, 2013). DIE offers an interactive learning experience by creating an imaginary world where children can incorporate their knowledge, feelings, and fantasies into the educational content (Poston-Anderson, 2008).

Nevertheless, this study revealed some challenges of using DIE strategies in science play. To address these challenges, the following recommendations are proposed: (1) DIE strategies should be used effectively in teacher training curricula for early childhood science education. The current study revealed that DIE strategies can increase children's interest in science exploration. However, the use of DIE strategies requires student teachers to have specialized knowledge about how to apply DIE strategies to the selected content and how to plan DIE activities (Özbek, 2014). Therefore, integrating lessons on DIE strategies into early childhood science education training courses is recommended. (2) Preschool teachers should be educated in the use of DIE strategies. The current study revealed numerous challenges involved in integrating DIE strategies into science play. Therefore, sufficient funds should be made available for inviting DIE experts to coteach and provide suggestions to student-teachers in a timely manner. (3) Empirical research should be conducted on the use of DIE

strategies in early science education. The current study revealed that numerous problems remain unresolved in terms of designing dramas in early science education. (e.g., excessively complex dramas may confuse children). To resolve these issues, additional empirical research must be conducted to form a comprehensive theoretical basis. Moreover, the evidence on the application of DIE strategies in early science education is scant (Akyol et al., 2018), so researchers should analyze successful cases to highlight effective examples for practical application. Finally, because of time and funding constraints, the current study did not enable student-teachers to implement various forms of DIE strategies (e.g., role playing, imitation, and improvisation). Therefore, future studies should explore possible methods for incorporating various drama strategies into children's science play and analyze the effects of these methods. Finally, future studies should adopt a pretest–posttest model to evaluate the effects of integrating DIE strategies into science play.

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