EUROPEAN JOURNAL OF STEM EDUCATION

European Journal of STEM Education, 2024, 9(1), 05
ISSN: 2468-4368

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Investigating Pre-Service Teachers' Satisfaction of Integrating Drama-Based Activities into Practical Science Teaching

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Citation: Huang, C.-H., Chen, Y.-L. and Haas, H. (2024). Investigating Pre-Service Teachers' Satisfaction of Integrating Drama-Based Activities into Practical Science Teaching. *European Journal of STEM Education*, 9(1), 05. https://doi.org/10.20897/ejsteme/14373

Published: March 21, 2024

ABSTRACT

This study explored the views of 63 Taiwanese pre-service teachers who had participated in a workshop about the value of integrating drama-based approaches in their practical science learning. It was primarily designed to investigate the pedagogical approach of Heathcote and other founders of process drama. In addition, it examined specific claims that it immerses learners in an enjoyable and social learning environment (Poston-Anderson, 2008; Lin, 2017) and that learners can practice core scientific skills such as making predictions, observing, and then validating their predictions (Weisberg et al., 2016). Following the workshop, participants completed an anonymized online questionnaire. Descriptive data analysis indicated that most participants (75%) strongly agreed that integrating drama-based approaches into practical science teaching was satisfying. Of the remainder, 20.7% agreed, 2.1% neither agreed nor disagreed, 2.2% disagreed, and none strongly disagreed with this statement. Moreover, 34.9% of the participants lacked opportunities to experience improvisation and integration of drama-based teaching in practical science. The study indicated that a drama-based approach can be a highly effective strategy for enhancing practical science teaching among pre-service teachers. Furthermore, the findings provide valuable insights into the factors influencing drama-based teaching in practical science. They suggest it could be an excellent strategy to stimulate learners' interest in science and interdisciplinary science-related subjects and improve their science skills. Teachers could thus provide young children with similar drama-based teaching in practical science activities to promote their learning of science. Finally, the study offers a set of important recommendations for future pedagogical policymaking and further research by drama-based practitioners.

Keywords: improvisation, drama-based learning, practical science, Taiwan

BACKGROUND OF THIS STUDY AND THE STATEMENT OF THE PROBLEM

Incorporating drama-based pedagogy into science teaching in Taiwan is challenging because science educators lack relevant training and the opportunity to practice it. It is also an under-represented area of research, perhaps because it is time-consuming and requires significant effort. It requires the involvement and cooperation of a strong and professional interdisciplinary team who can work closely together. Thus, it is not easy or quick to complete such studies (whether they involve quantitative or qualitative approaches), and few researchers and science educators conduct investigations of drama-based teaching in practical science. However, as an educator responsible for training pre-service teachers, I undertook this challenge because it has important implications for a wide range of educators today. Learning or teaching science can benefit by being more situated in and related to

the real world and embracing the complexity of social and human dimensions that link with daily life experiences. Drama-based pedagogy can help educators to address these aims.

Therefore, the drama-based approach of this study was mainly based on that of British founders of drama pedagogy (i.e., Bolton, 1979, 1984; Heathcote, 1967, 1991b, 2002; O'Toole, 1992; Way, 1967). The investigator applied their drama pedagogy to operate the educative dimensions of science, particularly focusing on Heathcote's drama pedagogy because she believed that there is no curriculum that cannot be expressed through drama and because she was committed to enhancing her students' understanding of the living world through dramatic experience. In addition, drama-based approaches can enable learners to release powerful energy on their own, thereby strengthening the pedagogical theory and defining the dramatic experience as a learning process. An educator's lively and emotionally rich performance can provide a learning platform for all students. The class reveals new insights and understandings, and the drama becomes an important means of exploring issues and pursuing knowledge. Therefore, the study used Heathcote's drama pedagogy in Taiwan to investigate participants' views towards drama-based teaching in practical science and examine the potential influence of cultural differences in how drama-based learning can be delivered.

Research Question

The study aimed to investigate the satisfaction of Taiwanese pre-service teachers regarding the application of drama-based learning in practical science teaching. It also aimed to solve the main challenges for science educators and pre-service teachers, who lack both the opportunities to practice drama-based approaches as well as training on using drama-based pedagogy in their science teaching.

Sub-questions

1. Are Taiwanese pre-service teachers satisfied when they receive a workshop on drama-based teaching in practical science?
2. Do they feel satisfied about integrating a drama-based approach into practical science teaching?
3. Is there a significant cultural difference in employing Heathcote's (and others') drama-based pedagogy (developed in Britain) among Taiwanese pre-service teachers?

LITERATURE REVIEW

The Founders of Drama Education

As a teaching methodology, process drama developed primarily from the work of leading drama practitioners such as Bolton (1979, 1984), Heathcote (1967, 1991b, 2002), O'Neill (1995), O'Toole (1992), and Way (1967). These British scholars generally believed that drama has two major functions: to allow students to grow and to promote students' learning of a subject.

Over the past century, British drama scholars have emerged in large numbers. Their efforts have enabled drama education to make great strides in the UK. Indeed, its influence has spread throughout the UK and the English-speaking world; it has also reached the Chinese region. Therefore, British drama courses have deeply influenced drama courses around the world. Drama was introduced to schools during educational reforms in various countries over the last century. Even today, drama pedagogy scholars, teacher trainers, and curriculum designers are based in the UK. Consequently, the teaching materials, lesson plans, teaching methods, and evaluation plans provided to teachers tend to be British-influenced. There is a strong flavor of British drama education, and many schools receiving training use teaching materials, lesson plans, and teaching methods provided by teaching artists as models for writing school-based drama courses.

Previous studies have used a variety of different terms to describe similar forms of drama-based pedagogy. For example, while Heathcote and other founders used the term 'process drama,' Austin and Sullivan (2019) discuss 'science shows,' 'science performances,' 'demonstration-based science shows,' or 'theatrical science shows.' Alternatively, Weisberg et al. discuss 'guided play,' while 'drama in education' is the term used by both Isyar and Akay (2017) and Chen and Huang (2022). However, this study incorporated the terms 'drama-based learning' to refer to the process from the student's perspective, 'drama-based teaching' to refer to the teacher's perspective, and 'drama-based pedagogy' to refer to the method in general. These related terms seem appropriate because they accurately reflect the nature of the approach from different perspectives, enabling a more standardized but nuanced description of the activities, which other researchers may also find helpful in the future.

What Is Process Drama?

O'Neill (1995) discussed the benefits of using process drama in a theater classroom. Process drama allows the theater specialist to develop a dramatic world beyond the boundaries of a written script. Drama worlds are examined in the complex improvised event called process drama; teachers and directors discover effective ways to explore these worlds and achieve a significant dramatic experience for participants. Process drama can help educators improve their explanations of concepts to students. In addition, creating a dramatic situation and a fictional world, which both teachers and students share, enables everyone to explore and verify their different ideas, issues, relationships, and contexts. In addition, O'Neill (1995) suggested that, whether in the classroom or on the stage, process drama enabled the creation of a fantasy world that lets everyone 'believe it to be true,' get involved in it, and accept its boundaries. Role-playing was an important concept in her work. Playing other people can transcend one's daily life, overcome one's constraints, and provide a glimpse of a possible and alternative self. She insisted that rather than saying that educational drama can solve problems or find answers, it is better to say that it relieves students from their constraints and recognizes their problems.

In process drama, students and teachers design roles and scenarios to explore issues, events, and relationships. The focus is on students' exploratory experiences and processes, rather than an end product, to measure their learning (Kao and O'Neill, 1998). It is a method of teaching and learning where both the students and teacher are working in and out of roles. For example, a teacher might play the role of the Pied Piper, leading the rats (performed by the children) to their deaths. Another example would be when teachers lead a group meeting on a topic (e.g., a discussion about building a new motorway through a village). As a teaching methodology, process drama developed primarily from the work of Bolton (1979, 1984), Heathcote (1967, 1991b, 2002), O'Neill (1995), O'Toole (1992), Way (1967), and other leading drama practitioners. Process drama is not about creating 'a product' (i.e., it does not result in a play or other form of performance); instead, it is about defining and creating a role and going through the 'process' of acting and responding in that role. Put simply, process drama is an experiential method of working that differs from other forms of drama in that the process is a product in itself (see https://www.artsonthemove.co.uk/education/process-drama.php).

In addition, although planning and preparation occur before the drama, process drama is unscripted. The teacher sets the boundaries and expectations, but the drama itself is improvised and usually spontaneous. Usually, the teacher works in their role to establish and maintain the drama. This does not have to be 'an Oscar-winning performance': if the drama setting has been clearly established, simply announcing that one is now 'in character' should be sufficient. Working in character enables the teacher to move the drama forward by questioning and challenging students, organizing their thinking, responding to and involving them, and managing their difficulties. Working in character means the teacher can develop and direct the drama more easily.

The main aim of this study was to examine such issues in Taiwan. The investigator took on the challenge of developing Taiwanese drama-based teaching in practical science curricula among Taiwanese pre-service teachers. The study's theoretical concepts and methodologies were mainly based on integrating drama into practical science through interactions between learners and lecturers.

Weisberg et al. (2016) defined "science play" as adults leading children's play activities by integrating questions into drama, aiming to encourage children to become involved in science exploration through prediction, observation, practice, and verification. Howell et al. (2023) reported that children could learn to interact with science through real-world experiences. In addition, Austin and Sullivan (2019) stated that the purpose of drama-based teaching was primarily to stimulate and inspire learners, increasing their motivation to participate in an enjoyable learning environment. Lin (2017) claimed that, through drama, children experience and learn to understand others' thoughts, including oral expression, vocabulary comprehension, and social interaction, because drama enables students to enhance their understanding of the real world. In addition, taking part in drama can allow learners to release powerful energy on their own, strengthening drama-based pedagogy as a learning process. Thus, during science-based dramas, children explore a scientific phenomenon while improving their social and language skills at the same time.

Furthermore, Austin and Sullivan (2019) stated that drama-based learning combines scientific content with theatrical techniques to engage audiences with science. Thus, drama-based teaching has been commonly used in informal science learning—particularly in science centers, schools, and museums—despite the fragmented evidence concerning its effectiveness. The authors collated the literature into a comprehensive review of the history, typology, and evidence base for science performance. They drew on various sources, including a discussion of research, classroom demonstrations, and drama used in schools, museums, museum theatres, and informal science learning. They concluded that both qualitative and quantitative evidence supported the use of drama in informal science learning and school curricula.

Drama-based teaching in science, using demonstrations linked by a common theme, has successfully produced both cognitive and affective outcomes, and theatrical science dramas have frequently been used to stimulate awareness and discussion about complex and controversial science-related issues, such as HIV-AIDS and human

cloning (Austin and Sullivan, 2019). Therefore, the critical features of structure, emotion, and audience involvement in good drama make this method a highly valuable and effective tool for formal and informal science learning. However, further research is needed to investigate its long-term impact on science performance.

Chen and Huang (2022) studied the reflections of 21 pre-service teachers who used drama to motivate young children's science learning during a "creative science activity designed for young children" course at a teacher development program in southern Taiwan. The pre-service teachers participated by developing drama activities and implementing them for preschool children. The findings indicated that pre-service teachers who adopted drama-based strategies (i.e., warm-up, improvisation, and story role-play) considered that it aroused the children's motivation to engage in the drama. It indicated that if drama-based teaching was integrated into Science, Technology, Engineering, Arts, and Math (STEAM), it could motivate learners' curiosity and motivation to learn.

Studies of Using Drama in Practical Science Teaching

McCaslin (2006) argued that through exploration, investigation, or experience, drama activities can assist learners in understanding and attract their attention to promote learning motivations and interests. During the drama, learners are both the audience and the problem solvers; they can establish a direct and interactive relationship to arouse their learning motivation and effectiveness. Poston-Anderson (2008) stated that supporters of drama-based pedagogy claim it is the only teaching method that allows learners to become immersed in an enjoyable learning environment in which they can freely participate. In addition, Zhang (2014) claimed that scientific curriculum design might apply drama-based activities in practical science education by integrating improvisation, modeling, and storytelling with role-play to achieve teaching goals, using various tasks to promote young children's interests and motivation.

In addition, Weisberg et al. (2016) stated that competing trends in early childhood education emphasize the need for both a strong curricular approach and unfettered exploration. Guided play is an early learning approach that reconciles these conflicting demands. It takes advantage of children's natural propensity to learn through play, allowing them to express their autonomy within a prepared environment under adult supervision. Weisberg et al. provided examples of how guided play situations have been implemented in past work. They showed that guided play is a successful educational strategy across different content, perhaps more successful than other pedagogical approaches.

Moreover, Faulkner et al. (2006) and Heras and Tàbara (2016) stated that the process of play could inspire creative learning. These authors did not emphasize that learners should "remember science knowledge"; instead, they focused on leading learners toward the scientific learning environment and having enjoyable interactions. Children learn better about science creativity, interpretation, and application by absorbing them. In other words, science, languages, or other subjects could be learned in this practical way or their day-to-day real-world experiences. Isyar and Akay (2017) claimed that drama-based learning stimulates children's motivation and interest across various subjects, including math and science. Lin (2017) also stated that many studies confirm that drama-based learning in science connects with various educational subjects, promoting interest in learning among children of different ages. Learners can use their physical movements and voices to explain conditions or difficulties encountered by experiencing participation and problem-solving processes.

Compared with traditional teaching strategies, Lin (2017) claimed that the main strength of drama-based teaching is its use of virtual reality through improvisation, experiencing, modeling, or role-play to achieve educative goals. These techniques empower learners to use their imagination, expressive thinking, exploration, and learning freely and independently. Drama could be implemented into learning activities in various fields, including language, science, and the arts. Therefore, drama-based approaches could provide a flexible and active learning environment where teachers can lead learners into imaginative scenarios. This process allows teachers to ask specific questions, have learners participate in improvisation, and lead learners in experiencing, discussing, and solving problems.

Integrating drama-based teaching in practical science means that learners are not only performers, audiences, and participants but also problem solvers. Meanwhile, teachers are performers, audiences, participants, and learning companions, among other things. Indeed, both teachers and students play multiple roles, whether as learners or teaching performers. In this way, sharing information can strengthen the interactive relationship between the learner and the teacher. Lin (2017) also mentioned that when teachers act as companions, they provide a flexible and lively teaching environment, guide learners into the dramatic plot, ask questions, and guide learners to discuss and decide on solving strategies through impromptu performances.

According to Pentassuglia and Boylan (2017), presenting science as a dance performance is unscientific; however, for creators, this technique can promote cognitive content construction and engage participants. The best interpretation of cross-field practice was when scientific concepts were regarded as performance materials. Cognitive content is a specific interpretation of art and science as mutually constitutive.

Furthermore, Ong et al. (2020) reported the effects of creative drama on situational interest, career interest, and science-related attitudes of science and non-science majors. Fifty-five science majors and 28 non-science

majors from five high schools in Malaysia voluntarily participated in a creative drama activity in Taiwan. Participants completed pre-tests on 'The Individual Interest Questionnaire' and the 'Test of Science-Related Attitudes.' They designed, prepared, and presented their creative drama during the 5-day activity, after which a post-test survey was administered. The career interests and science-related attitudes of science students were significantly improved. Students commented that creative drama had developed their courage, social skills, teamwork, creativity, self-reflection, presentation skills, critical thinking, and problem-solving skills. These results suggest that creative drama theater could be an alternative way to enhance scientific interest, future career aspirations, science-related attitudes, and soft power skills.

Deng (2020) conducted a fairy tale performance to explore scientific concepts created by teachers and students. Taking the children's drama 'Cinderella' as an example, the research was conducted using interviews. The results indicated that the 'improvisation process' was regarded as a reliable game. Freedom, inquiry, and collaboration strategies were provided in the play so that students could understand scientific concepts, discover problems, guess solutions, create learning opportunities, and participate in on-site creative practice in the process of dramatic dialogue. The long-term experience of the learners in the fairy tale plot, through the children exploring the situation together, might be helpful in art-based science education.

Furthermore, Chen and Huang (2022) researched the experiences of 21 pre-service teachers through warm-up, improvisation, experiencing, and story role-playing to investigate whether drama could improve children's learning motivation in science. They verified that integrating drama-based learning in practical science teaching was an exciting application of scientific inquiry learning and practical research. Huang et al. (2021) conducted a study on 48 pre-service teachers where drama was integrated into practical science education. The results showed that 87.5% indicated they 'strongly agreed' or 'agreed' with the overall planning of practical science activities. In total, 89.6% 'strongly agreed' or 'agreed' that experiencing the activity was helpful to their learning. Furthermore, 89.6% 'strongly agreed' or 'agreed' that they would apply drama-based approaches in practical science skills at home and in school in the future.

In summary, the studies cited above have indicated that drama-based teaching is an effective strategy to improve learners' understanding and interest in science. Depending on their perspectives, researchers have interchangeably used various terms, including drama-based teaching, science-playing, and creative drama in science; however, this study only employed drama-based learning or teaching instead of other terms. The study hypothesizes that integrating the drama-based approaches into practical science significantly enhances the learner's interest and motivation.

METHODS

The study adopted a questionnaire survey research design. An online questionnaire, using 5-point Likert scales, was administered following the activity. These were analyzed using SPSS (version 21) to obtain descriptive statistics. The research aimed to investigate the satisfaction and reflections of 63 pre-service teachers, who each volunteered to participate in drama-based learning of practical science. Their participation included warm-up activities, improvisation, role play, and linking scientific phenomena to composing scientific stories. The experimental activity was not a formal curriculum and learning activity. It focused on drama-based activities for all participants. The study took place across two 4-hour workshops (3:30–7.30 pm on September 30th, 2022, and 6:00–10:00 pm on October 3rd, 2022). About half (30–33) of the 63 participants took part in the first workshop; the remainder participated in the second.

Participants

Sixty-three pre-service teachers volunteered to participate in the experimental workshop. They were required to be proficient in listening and speaking in English and to have relevant professional educational knowledge. Most were female (82.5%), with 17.5% males. The main study focus of participants was early childhood education (56%), followed by special education (32%) and science communication (13%). Teaching participants included one lecturer (Mr. H) and two English-Chinese translators. Mr. H. was a consultant and a professional actor from Germany who participated in the drama seed project; he has worked in drama-based approaches to practical science for many years.

Instruments

Anonymous online questionnaires were used in the study, using 5-point Likert scales to collect all data. Each participant spent about ten minutes completing the 'Satisfaction of Applying Drama-Based Approaches in Practical Science' questionnaire. The alternative teaching material included a demonstration of Archimedes' principle

through lively verbal and physical language. The lecture assistant immediately summarized Mr. H's words by accurately translating Chinese and English.

This research investigated the pre-service teachers' perceptions of drama-based activities in practical science learning alongside various environmental and psychological factors. The study incorporated a quantitative exploratory design to examine five key elements:

(a) learning interest and motivation,
(b) cognitive aspects,
(c) use of drama in learning practical science skills,
(d) affective aspects,
(e) inspiring reflections, as well as other factors (i.e., learning environment, various material preparation and related equipment, perceptions of the importance of mathematics/science, and fear of asking math/science questions).

Procedure

A brief description of Mr. H's teaching steps is provided in the following:

1. First, Mr. H explained simple, easy-to-understand scientific concepts through drama using examples from our daily lives—at home and in the classroom. He then picked up materials and demonstrated various critical scientific concepts through the dynamic screen from a camera, which aimed to arouse participants' interests and motivations.
2. To integrate drama activities into practical science, Mr. H told and demonstrated several important scientific stories about Archimedes to attract the participants' attention and motivation. The stories included, "Give me a fixed point, and I can move the earth!" This was based on the law of levers, balance, catapults, stacking run, moving pulley, the principle of buoyancy, and the principle of mirror reflection.
3. Mr. H asked questions about Archimedes' science stories. He invited the participants to solve related problems with him, aiming to build an interactive relationship between learners and teaching performers.
4. Participants in each group selected 17 experimental activities (including scientific concepts and phenomena with different orientations) and two English-guided learning sheets. A QR code and a short video film accompanied each guided learning sheet. Before they began, each group of participants scanned the QR code and studied the English-guided learning sheet and short video film together. After completing the above steps, each group chose at least two scientific activities from more than 100 materials to integrate drama-based learning and practical science activities.
5. During the activity, Mr. H and the research team used a video camera to physically observe and record the responses of each group of participants and the interactions between each group.
6. Finally, each group of participants had to use Archimedes' scientific principles to compile a short story. This story had to incorporate the solution to a relevant scientific problem and needed to include scientific themes and principles, the exploration process, and scientific phenomena. Furthermore, it had to be shared in Chinese or English on stage.

Data Analysis

Data were analyzed by implementing descriptive and inferential statistics to understand the participants' satisfaction and attitude toward drama-based practical science activities. Sixteen Likert scale questions were analyzed to generate percentages, followed by two open-ended qualitative questions to collect enlightening reflections from all participants. The data analyses included five key elements from the quantitative survey and the qualitative statements. These related to

(a) learning interest and motivation,
(b) cognitive aspects,
(c) using drama-based activities to learn practical science skills,
(d) affective aspects,
(e) inspiring reflections and other factors (i.e., learning environment, various material preparation, and related equipment, the perception of the importance of mathematics/science, and the fear of asking math/science questions).

RESULTS

The study's results, including the questionnaire results and reflections, are shown in **Figure 1**, **Figure 2** and **Table 1**. Q1–16 were Likert scale questions, and Q17–18 were open-ended questions that yielded qualitative reflections.

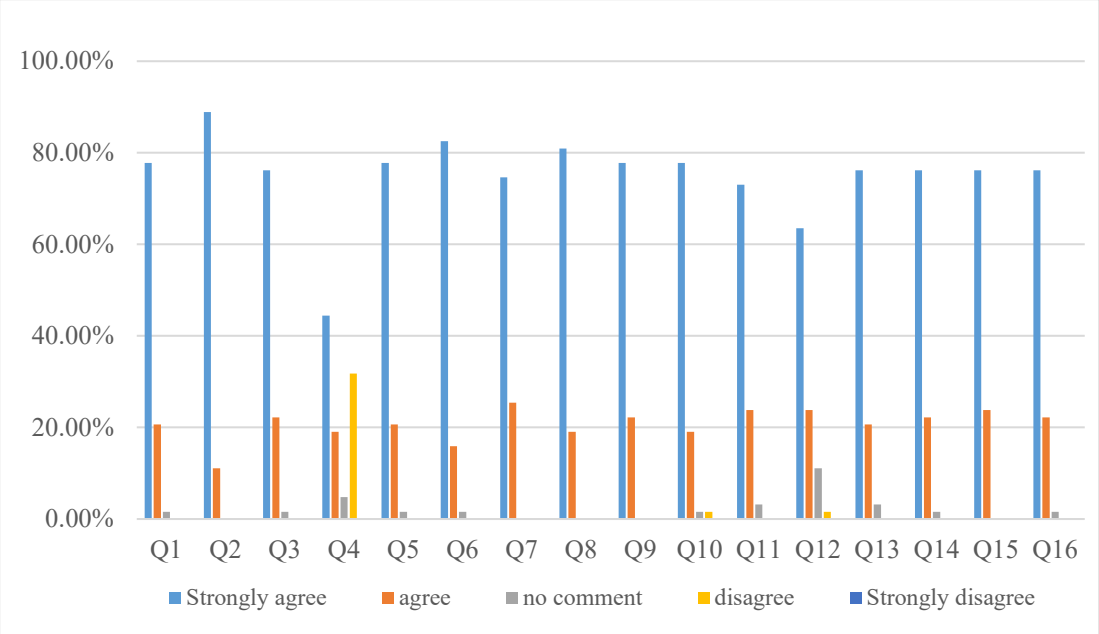

Figure 1. Satisfactions scores (%) of drama-based approach in practical science (*N*=63)

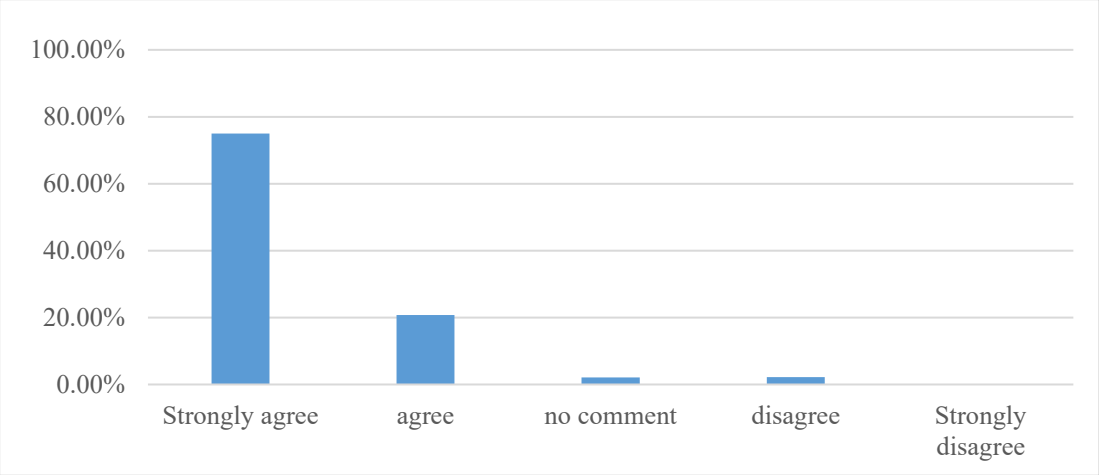

Figure 2. Average satisfaction of drama-based in practical science (*N*=63)

Table 1. Satisfaction scores (%) of drama-based approach in practical science (n=63)

Question	Strongly agree	Agree	No comment	Disagree	Strongly disagree
Q1	77.78	20.63	1.59	0.00	0.00
Q2	88.89	11.11	0.00	0.00	0.00
Q3	76.19	22.22	1.59	0.00	0.00
Q4	44.44	19.05	4.76	31.75	0.00
Q5	77.78	20.63	1.59	0.00	0.00
Q6	82.54	15.87	1.59	0.00	0.00
Q7	74.60	25.40	0.00	0.00	0.00
Q8	80.95	19.05	0.00	0.00	0.00
Q9	77.78	22.22	0.00	0.00	0.00
Q10	77.78	19.05	1.59	1.59	0.00
Q11	73.02	23.81	3.17	0.00	0.00
Q12	63.49	23.81	11.11	1.59	0.00
Q13	76.19	20.63	3.17	0.00	0.00
Q14	76.19	22.22	1.59	0.00	0.00
Q15	76.19	23.81	0.00	0.00	0.00
Q16	76.19	22.22	1.59	0.00	0.00
Average	75.00	20.73	2.09	2.18	0.00

For the quantitative analyses, the investigator categorized 18 question items grouped into five main aspects (learning interest and motivation, cognitive aspects, using drama-based activities to learn practical science skills, affective aspects, inspiring reflections and others). The results were as follows:

1. Learning Interest and Motivation

Q1. 98.4% strongly agreed or agreed that they were satisfied with the physical space arrangement provided by the event.

Q3. 98.4% strongly agreed or agreed they had experienced a strong sense of participation in the event.

Q11. 96.8% strongly agreed or agreed that they were satisfied with the teaching materials provided in the activity.

These results were consistent with Lin (2017) and Wedekind and Holger (2021): learners' interest and motivation can be enhanced using simple equipment, interesting scientific phenomena, simple situation configuration, diverse activity design, and a lively activity process. These results were also consistent with studies by Faulkner et al. (2006) and Heras and Tàbara (2016).

Q4. 63.5% strongly agreed or agreed that they were curious about the theme and content of the event. 4.8% indicated that it was acceptable, while 31.8% disagreed.

Notably, this study suggested that more publicity could be provided to less-contacted or unconnected teachers in the future. Integrating drama-based activities in practical science-related experiential learning among university pre-service teachers and young children could enhance their interest and motivation to learn.

2. Cognitive Aspects

Q7. All participants (100%) strongly agreed or agreed that they could keep up with the teaching steps and pace.

Q9. 100% strongly agreed or agreed that they were satisfied with the professionalism and teaching skills of the teachers.

Q10. 96.8% strongly agreed or agreed that the content met their learning needs.

These results suggest that teachers could effectively guide learners, and learners had basic scientific cognitive concepts and skills. Teachers' professionalism and teaching skills had almost 100% approval.

3. Using Drama-Based Activities to Learn Practical Science Skills

Q12. 87.3% strongly agreed or agreed that integrating drama-based activities in practical science could help improve science professionals' abilities.

Q13. 96.8% strongly agreed or agreed that integrating drama-based activities in practical science could help improve their understanding of related teaching fields.

These results suggest that most participants agreed that integrating drama-based learning into practical science could improve scientific professional skills and enhance understanding of related teaching fields.

4. Affective Aspects

Q2. 100% strongly agreed or agreed that the teaching performance emphasized
the value of interaction and encouraged learners to ask questions or express their opinions.

Q5. 98.41% strongly agreed or agreed that teachers could sense the teaching atmosphere in the classroom and paid attention to learners' reactions as they listened to lectures.

Q6. 98.41% strongly agreed or agreed that teachers would answer learners' questions.

Q8. 100% strongly agreed or agreed that they were satisfied with the teachers' teaching methods and attitudes.

These results show that the teachers were willing to answer the learners' questions and that learners were satisfied. Satisfaction with teachers' overall teaching methods and attitudes reflected a positive interactive relationship between teachers and learners. This is consistent with the perspectives of Faulkner et al. (2006) and Heras and Tàbara (2016).

5. Inspiring Reflections and Others

Q14. 98.4% strongly agreed or agreed that the activity positively affected learning.

Q15. 100% strongly agreed or agreed that they were willing to integrate drama-based activities as a professional skill in practical scientific teaching activities in the future.

Q16. 98.4% strongly agreed or agreed that they were satisfied with the overall activity planning.

The results described above also corroborate the studies of Lin (2017) and Wedekind and Holger (2021). It would be helpful if the materials were derived from common scientific phenomena in our daily lives at home and at school, using simple equipment that is conveniently obtained, illustrating prominent and interesting scientific

phenomena with simple situation configuration, and designing diverse and lively activities to enhance learning interest, motivation, and effectiveness.

Overall, the results of this study were consistent with the studies of Faulkner et al. (2006), Heras and Tàbara (2016), Isyar and Akay (2017), Lin (2017), McCaslin (2006), Ong et al. (2020), Poston-Anderson (2008), Weisberg et al. (2016), Xu (2009), and Zhang (2014).

The analysis of satisfaction also highlighted why the pre-service teachers had these reactions during the various experimental activities. It explored their learning interests, motivation, cognitive aspects, use drama-based activities to learn practical science skills, affective aspects, and ability to inspire reflections and others. Therefore, future university teacher training units could refer to the empirical data for special, preschool, and elementary school teachers to learn how to integrate drama-based teaching in practical science to arouse children's interests and motivations.

The results of this study corroborated those of Ong et al. (2020). The open-ended qualitative description answered by the 63 participants was summarized into four major aspects: learning interest and motivation, cognitive aspects, drama-based skills, and affective aspects. The following sections provide representative descriptions of these four aspects by the qualitative samples of 63 participants.

1. Participant Statements Regarding Learning Interest and Motivation

The following descriptions were from some of the 63 participants' qualitative statements: (P1) The experiment is very special and interesting. (P2) Relaxing and fun immersion in science activities. (P3) Realizing theories in teaching can increase students' learning motivation, and I hope that I can do the same when I become a teacher in the future. (P4) I like science more. (P5) Science education is super interesting. (P6) The process is more important than the result—I am very happy to participate in this activity; it is interesting and fun.

2. Participant Statements Regarding Cognitive Aspects

(P1) Understand the reasons behind many physical or scientific phenomena in the real-world. (P2) Use stories or games to bring in the topics we want to teach. (S3) Combination of science games and drama. (P4) Science materials can use life materials to play with unexpected results. (P5) What is important is not the scientific principle but the process of inquiry. (P6) Learned a lot of scientific knowledge and the skills of connecting stories. (P7) Recognized different scientific principles in a fun, simple, and fast way. (P8) Discovered many interesting and cool natural phenomena. (P9) Science is not that difficult! (P10) It was amazing to see many science game dramas.

3. Participant Statements Regarding Using Drama-Based Activities in Practical Science Skills

(P1) I learned how to apply drama-based activities in practical science to teaching! (P2) I learned how to introduce scientific principles from drama-based stories and how to interact with students. (P3) The biggest achievement is to apply drama-based activities in practical science to our daily lives with the materials at our fingertips. (P4) It's a great combination of teaching, games, and science. (P5) Learning to use drama-playing stories to bring into science teaching. (S6) Using stories or games to bring in the topics we want to teach. (P7) Combination of scientific games and drama-based activities. (P8) Knowing how to combine lessons with drama-based activities helps to improve learners' learning motivation. (P9) Science materials can apply everyday materials to drama-based activities with unexpected results. (P10) I learned much scientific knowledge and the skills of connecting stories. (P11) I learned about different scientific principles in a fun, simple, and fast way. (P12) I hope to pass on what I have learned today to more children in the future. (P13) I hope to apply the drama-based approaches I have learned today to teaching in the future.

4. Participant Statements Regarding Affective Aspects

(P1) The experiment is very special and quite interesting. (P2) Relaxing and fun immersion in drama-based learning in practical science activities. What matters is not the scientific principles but the process of inquiry. (P3) Be curious about everything and try it out. (P4) Be able to apply what they have learned today in teaching. (P5) Hope to have more opportunities to communicate with German scholars in the future. (P6) Learn happily, do my best, and play boldly. (P7) Hope to bring science into future self-designed courses. (P8) I wish I could play more creatively. (P9) Doing it by hand is more important than memorizing theory. (P10) The teacher is great, and we can continue to have similar activities in the future. (P11) The process is more important than the result—I am very happy to participate in this event; it is interesting and fun. (P12) I hope to pass on what I have learned today to more children in the future.

5. Participant Statements Regarding Inspiring Reflections and Others

The participants' responses were very positive, mostly in cognitive aspects, drama-based skills, and affective aspects, such as: 'very interesting,' 'very creative,' 'great,' 'very funny,' 'impressive,' 'can be used in daily lives or teaching,' 'interesting scientific activities,' 'interesting and fun,' 'hands-on science is more important than being theoretical,' 'drama-playing in practical science is very creative,' 'like science,' and 'hope to meet Mr. H again.' Therefore, educational teacher training units could provide similar related activities in the future: 'If the epidemic eases, inviting Mr. H to teach in person will give a more in-depth experience.'

These statements indicate the significant potential of integrating drama-based approaches into teaching practical science. When speaking to learners, teachers must constantly adjust the teaching steps or the depth and difficulty of scientific concepts and guide learning using dynamic evaluation to maximize development potential. This should align with the specific needs of children with mild learning, physical, or mental disabilities at preschool or elementary school.

Overall, this research used a drama-based approach as an intervention in practical science teaching. An observable change occurred in most participants following the intervention. Therefore, the study proposes a drama-based learning approach, incorporating both learning and collaboration, can mediate teachers' thinking in the context of drama-based learning designs. In addition, the qualitative results indicated that most participants were satisfied with the drama activities and Mr. H's lively approach to practical science teaching. A positive correlation was computed between 'quality of teaching,' 'satisfaction with drama-playing in practical science,' and 'recognition of the importance and implementation of mathematics/science for future teaching,' based on both quantitative and qualitative results. However, the 'fear of asking mathematics/science questions' was found to be slightly negatively associated with 'drama-based activities to learn practical science skills' because of the fear of speaking English and the fact that it was the pre-service teachers' first time experiencing drama-based learning in practical science.

Moreover, there are several benefits of applying drama-based approaches in scientific inquiry, experiments, and concept learning (other outcome variables to be evaluated). This is because learning occurs through drama-based approaches during scientific inquiry or experimentation. Many results in scientific inquiry cannot be expected or predicted in advance. This could highlight the importance of integrating drama-based activities into practical science. For example, the same teacher used Archimedes' scientific concepts to conduct the drama through various experiences and activities for different participants. The scientific inquiries and experiments presented would differ, but the expected learning of scientific concepts could improve their learning performance and skills. Drama-based approaches can enrich teaching and learning as well as it can foster learners' creative engagement and their imaginative development. It seems by bridging the arts and the science for both teachers and learners.

DISCUSSION

First, in response to the fourth question, 'Were you curious about the theme and content?', 63.5% of the participants strongly agreed or agreed, while 4.8% indicated that it was acceptable, and 31.8% disagreed. In addition, the drama-based activities were found to have triggered situational interest in learning science in students whose major was either special education or early childhood education. The Department of Special Education participants were relatively passive in their willingness to participate and completed only two basic activities. In contrast, a few groups from other major subjects were willing to try to use different materials to conduct a third or other experience or activity. For example, the Department of Early Childhood Education participants were very willing to participate—they completed a third or other activity. Most also actively tried to use various materials to conduct multiple experiential activities. They were highly motivated and willing to learn about integrating drama into practical science education and had high levels of immersion in the unpredictable and perceptually playful scientific exploration. Additionally, they had an interactive relationship, showed a willingness to participate, established good interactive relationships, acted flexibly, used diverse creativity, showed fun facial expressions or exclaimed praise, and were good at using scientific principles. Consequently, they constructed a complete scientific story and volunteered to share various scientific research processes and results in English or German. Therefore, this study suggests that more relevant experiencing activities could be promoted and provided to college educators and pre-service teachers who have not yet integrated the drama-based approach in their practical science teaching to enhance students' learning attitudes, motivation, and interest.

Second, due to the COVID-19 pandemic, a multi-faceted assessment considered factors such as relevant situational conditions and non-native language teaching, minimizing the risk of internal and external control variables. For example, Mr. H could not come to Taiwan for physical teaching and switched to video teaching. To facilitate the implementation of this study, we recruited pre-service teachers of young children with basic English

listening and speaking skills who had studied relevant educational theories and teaching strategies; even so, this remained a significant limitation.

Third, the reactions and feedback of the pre-service teachers—especially regarding cognitive aspects, drama-based activities to learn practical science skills, and affective aspects—contained enlightening reflections. These are worthy of use as future course content or experience for improving science education by training units for university pre-service teachers. This could strengthen the training of pre-service teachers and teachers of young children to improve their learning interest, motivation, and professional development.

CONCLUSIONS AND SUGGESTIONS

Conclusions

This study concludes that the impact of integrating drama-based teaching into practical science was important and useful for the majority of the sample of 63 pre-service teachers. Therefore, drama-based approaches in practical science can be a highly effective strategy for enhancing science concepts. Integrating drama-based activities into practical science teaching positively impacted Taiwanese pre-service teachers. The results addressed three research hypotheses and represented consistency with drama-based pedagogy and findings from researchers such as Heathcote (1967, 1991a, 1992), Chen and Huang (2022), Poston-Anderson (2008), Lin (2017), Weisberg et al. (2016), and Zhang (2014). In addition, the results of this study corresponded with the research hypothesis that there were no significant cultural differences between the UK, USA, and Germany in terms of employing Heathcote's and others' process drama pedagogy.

Teaching Suggestions

1. Increasing experimental activities to promote the integration of drama-based teaching in practical science. This study suggests that pre-service teacher training units could significantly increase activities involving drama in practical science or the course setting of micro-credits to enhance the quality of teacher education training programs. These programs can incorporate professional drama skills in practical science and help cultivate core literacy.
2. Increasing the provision of lessons integrating drama-based learning in practical science. The results indicated that using the drama-based approach in practical science had a significant effect on Taiwanese pre-service teachers. Therefore, this study recommends that the relevant education authorities or school units should significantly increase the provision of drama-based teaching in practical science education. The number of science education sessions can even be fully utilized in the morning, recess, or after-school periods to comprehensively increase the number of participation hours in diversified drama activities in practical science education. This will be beneficial to students' science education.
3. Allowing participants to choose practical science courses with a drama-based learning approach. More inter-professional credits of drama-based learning in practical science could be offered in the relevant training programs for preschool or elementary school teachers so that more teachers can gain relevant professional knowledge and abilities. In the future, this group of new educational pioneers could engage in special education-related classes to integrate drama-based approaches in practical science further, providing multiple benefits.
4. Strengthen the elective courses of drama-based approaches in practical science for pre-service teachers. It is recommended that more professional credits for drama-based learning in practical science education should be offered for special education teacher training, so that more teachers have relevant interdisciplinary and cross-disciplinary skills. The drama-based approach integrates scientific professional knowledge and cultivates pre-service teachers and science educators with more professional scientific and interdisciplinary knowledge and skills. In the future, this new group of education leaders will enter special education-related classes to implement the drama-based approach in practical science education. This will not only increase their professional knowledge but also help students with disabilities integrate science into drama activities. The improvement of education has significantly helped such students, and it can be said that there are many benefits to them.

Research Suggestions

The study's results may not be able to be generalized across different educational stages, departments, or genders because there were only 63 participants in this study. We therefore suggest, first, that future researchers should conduct empirical research across departments, grades, and situations using pre-test and post-test research designs. Research could be done on integrating the drama-based approach in practical science, comparing the

differences in learning performances and changes in all dimensions. Second, follow-up longitudinal or cross-sectional research could be conducted to explore the application of drama-based activities in practical science teaching and to compare the differences and changes in their actual application. Finally, as there are very few similar studies on this topic in Taiwan, the researcher would like to encourage other researchers to conduct more studies with a drama-based learning or teaching approach in practical science, and to analyze the similarities and differences of the findings across different situations, majors, ethnicities, and countries.

1. Research participants. There are only 63 pre-service teacher students in this study. The results of this study may not be extrapolated to other studies in the parent group of pre-service teacher students, nor to different educational stages or different pre-service teacher students. Regarding the effectiveness of the intervention by category, it is recommended to conduct experimental research on experimental and control groups, or consider conducting relevant research on integrating drama-based learning in practical science through cross-group, cross-department technology, or cross-situation comparisons. Furthermore, studies should compare various aspects of science education and differences in performance and changes.
2. Research design. This study adopted a questionnaire survey design, meaning the results can be replicated and compared. It is recommended that future research should also investigate the long-term impact on science performance.
3. A follow-up study of the 63 pre-service teachers is investigating how they apply drama-based approaches in practical science teaching for young children or children with special needs. In addition, it aims to investigate their attitudes toward drama-based approaches in practical science, both at home and in their classroom.

Overall, the study examined a drama-based approach within a practical science framework. It incorporated both learning design and collaboration to mediate teachers' thinking in using drama in practical science learning. Significantly, this study offers important recommendations for future policymaking to cultivate Taiwanese pre-service teachers and encourages further research investigation and drama practitioners in this area. In addition, the literature focused on teachers as the key to successfully implementing drama-based teaching in practical science education. The investigator interviewed several participants privately during and after the workshop; several stated that being well-prepared and well-equipped is critical when preparing students for drama-based learning in practical science. Therefore, teachers' thinking is also critical for their learning design, decision-making, and implementation of drama-based learning in practical science activities.

ACKNOWLEDGEMENTS

The authors wish to thank all participants for their time and energy in this study.

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