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Secondary Teacher Candidates' Perceptions and Experiences Before, During, and After Conducting A Science Show

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ABSTRACT

The science show is a form of informal science learning (ISL) that can potentially develop students' interest in science. However, there needs to be a gap in bridging the ISL elements, such as science shows, into formal teacher education programs as one innovative pedagogical approach. Thus, this study investigates how secondary science teacher candidates' perceptions of science displays shifted after carrying out their science shows and explores their shared experiences as part of their teacher training program. Data were collected from 16 secondary science teacher candidates of cohort 2020 based on their written reflections on their experiences before, during, and after conducting science shows. The study found that some science teacher candidates' perceptions of science shows had shifted, and the others had remained the same. The science teacher candidates' everyday experiences during the science show implementation were their effort to conduct a successful demonstration and develop video-making skills.

Keywords:

Science Show; Reflection; Experiences; Perceptions

ABSTRAK

Science show merupakan salah satu bentuk pembelajaran IPA informal (ISL) yang berpotensi untuk mengembangkan minat siswa terhadap sains. Namun, ada kesenjangan dalam menjembatani elemen ISL seperti pertunjukan sains ke dalam program pendidikan guru formal sebagai salah satu pendekatan pedagogis yang inovatif. Dengan demikian, penelitian ini menyelidiki bagaimana persepsi calon guru sains menengah tentang pertunjukan sains bergeser setelah melakukan pertunjukan sains mereka dan mengeksplorasi pengalaman umum mereka sebagai bagian dari program pelatihan guru mereka. Data dikumpulkan dari 16 calon guru IPA SMP angkatan 2020 berdasarkan refleksi tertulis dari pengalaman mereka sebelum, selama, dan setelah proses pelaksanaan pertunjukan IPA. Studi ini menemukan beberapa persepsi calon guru sains tentang pertunjukan sains telah bergeser dan yang lainnya tetap sama. Pengalaman umum para calon guru IPA

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selama pelaksanaan pertunjukan IPA adalah upaya mereka dalam melakukan demonstrasi yang berhasil dan mengembangkan keterampilan pembuatan video.

***Kata kunci**:*

Pertunjukan Sains; Refleksi; Pengalaman; Persepsi

1. Introduction

Teacher training programs in academic institutions have been advocating for student center pedagogy to promote meaningful learning for the students, which is in line with informal science learning (ISL) objectives. ISL allows people, especially young children, to engage and learn science. Most studies incorporating ISL elements into teacher training programs were implemented at the elementary or primary level. Roche et al. (2016) highlighted the importance of engaging adolescents compared to young children as that might influence the adolescents' decisions for future career pathways. These young adolescents are usually in the secondary level of education, where their interest in science can be sustained or declined depending on how science subjects are taught to them in school. This can shape their perception of science and their decision to take science subjects at the tertiary level to pursue a career in science.

Thus in this study, science show was introduced to secondary science teacher candidates as one of the pedagogical approaches used in teaching science concepts in one of the modules of the teacher training program in Brunei.

1.1 Background of the context

The science show was introduced to secondary science teacher candidates as one of the pedagogical approaches used in teaching science concepts in one of the modules of the teacher training program in Brunei in 2018. The program is Master of Teaching (MTeach), and the specific module is Learning Area 1: Science Education for Secondary School (LA1). MTeach comprises three semesters, and LA1 is offered in the first semester. One of the assignments for LA1 is for the science teacher candidates to implement and perform a science show in a group of two or three to a live audience. However, due to the COVID-19 outbreak, cohort 2020 students had to record their science show. The rationale for introducing science shows was to promote science awareness and engagement among science students via science shows. Science show emphasizes using interesting demonstrations that mostly require everyday materials rather than laboratory apparatus. Science show also demonstrates the application of science concepts in everyday life that students in school have learned in science classrooms.

The main objective of this study was to investigate the effects of implementing science show on secondary science teacher candidates' perceptions of science show and explore their shared experiences. Thus two main research questions are formulated in this study.

(1) How has science teacher candidates' perception of science shows changed before and after implementing their science show?
(2) What are the shared experiences among secondary science teacher candidates during the implementation of their science show?

1.2 Science show

Globally, there are growing initiatives to promote STEM education in formal education from policymakers to educators to meet the challenges and demands of a STEM-driven economy (Freeman et al., 2019). However, there are obstacles to effectively integrating STEM into formal education. One of the main challenges is the declining students' interest in STEM subjects. Thus, informal science learning is one of the initiatives to encourage the young generation to be interested in STEM. Tang and Zhang (2020) found that informal science learning significantly influenced science performance through science interest and self-efficacy for students who had sat for PISA in 2015 in the United Kingdom, Hong Kong, and South Korea. This informal science learning usually occurs in public places such as museums and science centers through exhibitions and festivals. One of the ways to engage these young students is to perform a science show. According to Watermeyer (2013, p. 3), 'science show attempts to reconcile the incongruence of the school and learners' everyday experiences.' Furthermore, science shows 'aim to stimulate participants' interest in science and technology through emphasizing their importance, ensuring that the scientific phenomena are linked to everyday life, and experiments presented on stage are to excite and amaze the audience.' (Karim & Author, 2020, p 297).

Science communicators are usually experts in the field, talking to younger generations who mostly attended formal schools. Good science communicators can use and connect students' everyday experiences to science concepts they want to convey. However, it is usually the scientists who are the experts in their field that possess advanced knowledge, which can be difficult for them to communicate effectively with the young students. This spurred research interest in science communication which is beyond the scope of this paper. Nonetheless, it is essential to note that most of the science shows were conducted by experts in public spaces such as museums and science centers, and most of the audience is young students. Although there were many studies, as mentioned in the literature review done by Wang et al. (2020), that looked into the impact of informal science learning on students' interests, attitudes, and motivation in STEM, there were very few studies that explicitly investigated the effect of science show on those same areas (Roche et al., 2016) and the ability of science show to promote scientific understanding among students (Karim & Author, 2020; Peleg, 2011; Kerby et al.,2010) found in the literature. Roche et al. (2016) highlighted the importance of engaging adolescents compared to young children as that might influence their future career paths. These young adolescents are usually in the secondary level of education, where their interest in science can be sustained or declined depending on how science subjects are taught to them in school, which can shape their perception of science and decision to take science subjects in tertiary level to pursue a career in science.

A common element between conducting practical or laboratory sessions with performing science shows is the demonstrations or the hands-on activities. Hofstein (2017) argued that there needs to be a match between science practicals or laboratories' objectives and what the students are doing during those sessions. His concluding summary further states that school practical or laboratory sessions are mainly 'hands-on,' ignoring the 'minds-on' aspect, which does not engage students in meaningful learning. Thus, introducing elements of science show into demonstration might help revive the overlooked and underestimated importance of school practical or laboratory sessions. Sadler (2017) found that audiences could recall 25% of live science demonstrations in an interactive science show after two and a half years without giving visual or verbal prompts. With verbal and visual prompts, the audiences could recall 50% of the live science demonstrations, which include elements of how things work during the demonstrations.

Furthermore, papers on integrating science show as an innovative pedagogy in secondary teacher training programs for science education have yet to be published. Thus, this study investigates the effect of science show as one of the pedagogies used in secondary science teacher training programs on science teacher candidates. In achieving this, science teacher candidates were required to reflect on their experiences before, during, and after conducting science shows. In preparing teachers, reflection is an important learning aspect for beginning teachers, and they continuously act upon it throughout their teaching life. The roots of reflection in teaching have been the work of John Dewey (1933, 1938).

Reflection is a dynamic and continuous learning process that allows for the meaning and connection of a person's experience to other experiences. For teachers, most reflections are done deliberately and intentionally rather than randomly. Science show activities provide a good opportunity for teachers to endeavor this experience. Science shows require the presenters to prepare well with their shows to engage their audience, as the success of a science show is reflected through the audience's active participation (Karim & Author, 2020). With thorough planning and preparation, teachers are required to be critical and reflective.

Furthermore, by preparing a science show, teachers would target the audience or their students to better understand the science concepts in the contexts that make sense to them. Science shows do provide not only a platform for a better teachers' reflection but also a constructivist view of experiential learning as "constructivism implies that the learners or the individuals are constructors of their knowledge which is generated by interacting with their socio-cultural environment" (Mughal & Zafar, 2011, p28). Moreover, the experiential learning component of doing science show provides teachers with instructional skills essential for developing better pedagogical knowledge.

Analyzing teachers' work and practices through their reflection is essential to provide meaningful learning experiences that lead to the continuity of the learning process as rooted in Dewey's criteria for reflection. Reflection, driven by wholeheartedness, open-mindedness, and responsibility, provides a better way of acknowledging one's awareness and knowledge of the experience (Dewey, 1933; Rodgers, 2002; Bakker, de Glopper, & de Vries, 2022).

The science show is a good platform for enhancing teachers' communication and hands-on learning skills. Additionally, science shows that include the making of videos allow the opportunity for teachers to develop technological skills. These technological skills can be used across different disciplines. They can be seen as an added value to teachers' repertoire, especially in this 21st-century education accelerated by the global outbreak of COVID-19. Technology incorporating science shows was suggested to be the future direction of this field. Roche et al. (2016) discussed using Poll Everywhere for interaction between the science show presenters and the audience. It reflected a more accurate picture of audience interaction during a live show.

2. Methods

2.1 Participants

Sixteen science teacher candidates involved in this study were from cohort 2020. There were pre-service teachers and in-service teachers within this cohort. The pre-service teachers had bachelor's degrees from different areas of science, such as a BSc in Biochemistry, a BSc in Biological Sciences, a BSc in Chemistry, and others. Few in-service teachers had completed their master's degrees in different fields, such as MSc in Systems Biology.

2.2 Procedure

As mentioned before, the science show was part of the assignment for LA1. In this assignment, the student-teacher candidates were expected to plan and perform their science show to a live audience in a group of 2 or 3 people. However, due to the first COVID-19 outbreak in March 2020, this cohort had to record their science show in a video presentation. Due to the format change, four student-teacher candidates decided to do a solo science show while the rest did the show in a group of 2. All student-teacher candidates would reflect on their experiences after conducting their science show as part of their assignment.

Unlike the previous cohorts, cohort 2020 was trained via video. One of the lecturers delivered the training content prepared by the SEL (Seria Energy Lab)'s science communicators in PowerPoint format. SEL was formerly the Oil and Gas Discovery Center (OGDC). SEL is a flagship program by Brunei Shell Petroleum Company that functions as a science center to support the growth of science literacy in the country. This cohort was asked to record their science show without an audience.

2.3 Format of reflective writing

Several promising practices in developing critical reflective practitioners were suggested (Yost et al., 2000; Roberts et al., 2021). One of the mentioned practices was writing experiences. The writing experiences approach in this study is guided by posing several questions to promote reflective thinking (Smyth, 1992; Kim, 2018). The reflection assignment was guided by a few prompts provided to the student-teacher candidates, as shown in Table 1.

2.4 Research approach

This qualitative study employed a phenomenological approach to investigating a phenomenon by interpreting the science teacher candidates' lived experiences via their reflective writing.

2.5 Data analysis

Thematic analysis was used to analyze the student-teacher candidates' reflection reports. Braun and Clarke's (2006) thematic analysis procedure was used in analyzing the students' reflective reports. The three researchers read the overall students' reflections, focusing on finding the emerging themes of the shifts in students' perspectives before, during, and after conducting science shows. Each researcher coded the students' reflections on their own, and after completion of the analysis, they met again to discuss the agreement on the themes and coding that emerged from the study. Any discrepancies in the coding are discussed and resolved through a consensus by the three researchers.

2.6 Trustworthiness

The MTeach students' science show videos were observed to complement the reflective reports and increase this research's credibility. However, the science show videos were not analyzed but only served as complementary data to support the reflective reports of the students.

Table 1. Guided prompts for the student-teacher candidates' reflection writing

Events that need to be included in your reflection	Some elements that need to be included in your reflection
Before your involvement in the science show	- What do you think of a science show? - Do science shows benefit science teachers in their teaching? In what way? - Do science shows to benefit the students in their learning? In what way?
The science shows preparation processes, i.e., planning, preparing, and implementing.	- What did you learn from your involvement in creating a science show? - Challenges that you faced? -Any rewarding/memorable experience?
After the science show	- What do you think of a science show? - What elements of science show that might be beneficial for science classroom teaching? - If you were allowed to do another science show, what would you do differently to improve the show?

3. Results and Discussion

In addressing research question 1, there were two themes emerged from the thematic analysis of the teacher candidates' reflections, i.e. (1) change of perceptions on science show and (2) no change in perceptions on science show,

3.1 Change of perceptions on a science show

Six student-teacher candidates clearly stated their change of perspective on science shows after conducting the science shows. Student A mentioned that science shows only benefit elementary students, not secondary students, as they, as secondary teachers in training, did not see it as necessary for secondary levels. Student A further explained that with the advancement of technology, technology in class could stimulate students' senses as much as science shows. Below is an excerpt from the student A reflection report on the science show before implementing the science show assignment.

> *As a secondary teacher myself, I found it unnecessary. Using advanced technology stimulates the students' senses, just like science shows. In addition, doing the experiments hands-on would give a much better experience and exposure. For elementary students, this would benefit the teacher greatly. As difficult as it is to handle children, speaking of classroom management, doing a science show would be an effective alternative for science teachers. Children usually have a short attention span and can get easily distracted. (Student A, before)*

However, after implementing the science shows assignment, student A was willing to integrate science shows in their future lessons to see the beneficial impact that it can bring on the students. Below is the student A reflection report excerpt after implementing the science show assignment.

> *I might integrate science shows in my future lessons to observe their beneficial impact on the students. The elements that benefit the teachers while implementing the science shows are the skills of demonstrations of the experiments. As well as the techniques used in science show to grab the audience's attention. (Student A, after)*

As for student B, before implementing the science shows assignment, she "found the whole video assignment challenging." This is because "to make a fun and interesting video, one must take on the role of an actor, whereby dramatic gestures and actions, as well as the intonation of speech, are required of them." Thus, it required them "to go out of my comfort zone." Nonetheless, after the implementation of the science show assignment, they found that "it was surprisingly a fun experience for both my partner and me, filled with lots of laughter as we worked together collaboratively in every aspect of the project, including in terms of decision making, problem-solving, creative planning, and constructive discussions." Due to this positive experience, they were eager to integrate some elements of science shows into their future teaching in the classroom.

Like student B, student C found doing a science show challenging because it took them out of their comfort zone. Nonetheless, after the science show assignment, they "considered the experience of doing this science show worth it and positively challenged me. Moreover, it made me aware that the passion and strategy would affect the student's engagement in a lesson activity." She further elaborated that "with a science show, students might see that science is simple, fun, and relevant to their lives, and that could inspire them to learn more about science."

Like students B and C, student D expressed that doing a science show required her to come out of her comfort zone due to the performing aspect of the science show, as shown in the excerpt below.

> *The word 'show' terrifies me. I am not a person who would like to put myself out there; my personality is not about performing. Before conducting the science show, I was honestly petrified that we had to put on a show in front of children of an unknown age range and observed by professional personnel. (Student D, before)*

Nonetheless, after doing the science show, the performing aspect has shifted into a more positive tone, as demonstrated in the excerpt below.

> *Staging a performance helps teachers to ensure their students' understanding is strengthened of specific topics and concepts, no matter whether they are difficult or easy. It would require teachers to do less explanation and provide opportunities for them to reflect on their teaching and, not to mention, build a rapport with their students while having fun. (Student D, after)*

As for student E, they had "never been to nor watched a science show and thought of it like a magic show by the name of it where the performer will do some gimmicks, and something will pop out of nowhere to capture the attention of the audience." Then after "being physically involved in creating the content of the science show," they had

> *learned that teaching science using materials outside of the laboratory can be more effective and appealing to the students as it is novel, diverting the idea that science is uninteresting and rigid. Following my participation in the science show, it would be entertaining from a student's perspective as the materials used and performance differed from what they usually see in the classroom. (Student E, after)*

Unlike the rest of the students mentioned above, student F has "an idea of what is a science show" as they grew up watching them on television. She elaborated, "As small children, we are not sure how these scientists on the television experiment, and we only watch them for fun, but for me, it developed my curiosity on how things work." However, she expressed her disappointment that, as a student in secondary science classes, the teacher

> *Never conducted this kind of science show-like experiment as it was one of my main reasons for joining the pure science stream. Instead, most of the experiments were repetitive or were carried out since it was required in the syllabus. (Student F, after)*

3.2 No change in perception

The rest of the science teacher candidates have yet to show any change in perception. However, most of their initial perception has already been positive towards science shows. For example, student G defined "science show as a performance with a story that revolves around a certain concept of science." The importance of *the story* was reiterated after implementing the science show, as shown

by the excerpt below.

> Making my science show is an approach that could help improve my student's understanding of certain concepts in my future lessons. As mentioned above, some aspects of a science show could benefit science classroom teaching, such as story-telling. (Student G, after)

This story element was also used in the student G science show video, which complemented the finding of the student's reflections.The findings indicated how the science teacher candidates changed their perspectives after implementing the science shows. The shift of belief and perceptions of the secondary science teacher candidates has elements of the three attributes a reflective individual should possess, especially open-mindedness and wholeheartedness (Dewey, 1933; Marshall et al., 2021). For open-mindedness, student A was willing to implement some elements that science shows can offer even though they initially found science shows unnecessary for secondary students; as for wholeheartedness, students B, C, and D had managed to overcome their challenge of feeling 'outside of their comfort zone' in doing a science show. In addressing research question 2, two themes have been identified, i.e., (1) effort in doing a demonstration and (2) video-making skills.

3.3 Underestimated the amount of effort in doing a demonstration

The importance of preparing and conducting trials to demonstrate any science experiment was highlighted. Most student-teacher candidates mentioned that "although the demonstration and explanation behind the show are super simple, the implementation was not. Simple shows do not necessarily mean simple preparation and creation." Some of the student-teacher candidates shared the challenges that range from "repeatedly trying to record the reaction of my eye, playing the lighting and phone settings so that it could record the best way possible and to chasing after the cat and making it cooperative enough to be recorded" to "gathering the materials for the tea bag rocket, I have difficulty in finding the appropriate teabag as the original demonstrator of the experiment either did not specifically state the type of teabag that should be used or mentioned the tea brand that did not exist in our local supermarket." and "the experiment requires around 3 to 4 hour freezing time, and the experiment does not necessarily work in one try as different factors such as temperature and disruption may affect the success rate."

With these unique experiences that each student-teacher candidate went through, they "found that conducting the trial runs was a crucial part of the preparation stage," and its implication in the classroom setting was that "teachers or demonstrators need to conduct activities first before presenting to students. We could identify or discover any potential risks arising from the experiments."

After conducting the science show, most science teacher candidates are more appreciative of the role of demonstration in science teaching. Their experiences regarding how much effort, time, and even cost in preparing the demonstrations made them realize how practical or laboratory sessions

have been taken for granted in science teaching. There is a similarity in the aim of science show (Roche et al., 2016; Watermeyer, 2013; Karim & Author, 2020) and practical or laboratory sessions (Hofstein, 2017) in schools where it is hoped that by 'doing science,' it would interest students in future scientific endeavors. However, student F revealed how the practical or laboratory sessions in school did not match her expectations with science shows they had seen when they were younger. This statement was corroborated by student D, who had never been exposed to science show before and had the impression that science was uninteresting and rigid. However, after implementing a science show in this module, science can be seen as exciting and fun for them and the students. Hence conducting a demonstration in the form of a science show might provide a platform to change students' perceptions of science and be more interested in science subjects.

3.4 Video making skills

Due to the outbreak of COVID-19, globally, education has to opt for online teaching and learning. The same transition also occurred during the implementation of the science show. Nonetheless, there was an unexpected benefit to this transition, which most science teacher candidates had stated was the video-making skills. The skills gained from video making were helpful in this assignment and applicable across the program and for online teaching. Some excerpts that highlight the theme were, "That said, my new skill in editing videos was one of the skills that I now plan to enhance more in the future as I believe I could use it for my own teaching experience.", "Creating this science show with video recordings also facilitates learning since I explored different digital platforms to make the video. This experience would help me integrate technology into my lessons in the future." "Apart from this assignment, I have used the skills to create a video across other curricula and in my online teaching in school."

Although some science teacher candidates found it challenging to make a video regarding the required skills and time, they also mentioned that seeing the final product was a rewarding experience. Some excerpts encapsulating this theme were, "Even though I struggle in the video editing, at the same time, I found it rewarding as I take time to learn to edit and compile the video. Now, I obtained some skills in video editing.", "Being the main creator of the video was a rewarding experience. Although the task is lengthy and complex, the skills I have acquired through this responsibility are invaluable." "The process of making this video was a valuable experience for me, as it offers opportunities for me to expand my technological knowledge."

Some of the science teacher candidates were equipped with video-making skills, and the ability to showcase that talent was very comforting for them, as shown by the excerpt below.

> *Having had some field experience with recording and editing, the idea of inserting an introductory opening video and making some explicit informative clips in between, in the end, came with the skills gained from experience. It was reassuring to find this skill applicable in the context of education*.

Furthermore, it has been recognized that integrating technology is significant in preparing teachers to be more effective in their teaching practices using technology integration (Gaytan & McEwen, 2010; Jassim, 2020; Wells, 2007; Yurtseven Avci, O'Dwyer & Lawson, 2019). Based on Kay's (2014) review of the literature on the use of videos in education has highlighted several benefits, such as the flexibility of learning in terms of time, pace, and location and the fact that students can watch the recorded lectures again if they were absent for a class, especially during the COVID-19 pandemic.

4. Conclusion

The findings of this study have flagged the positive use of science shows as a means of pedagogy. Although the science show was done through video recording and not like the familiar science show of live and face-to-face interaction, the objectives of conducting and performing the science show can still be achieved. The effects can be seen in the positive change of perceptions by several science teacher candidates.

This paper has shown how science shows could assist in developing science teacher candidates in upscaling their social skills, such as communication and collaboration. Additionally, using videos for the science show has allowed the teacher candidates to use video-making technology. Video-making skills benefit them during the COVID-19 pandemic as schools expect to perform blended learning. Furthermore, with the preparation of science shows, the teacher candidates were developing their research skills, such as when they found the science concepts to be performed and materials to be used. The whole experience of science shows has also encouraged the teacher candidates to be reflective and open-minded to options and choices in their pedagogical approaches. It was an exciting finding that despite how some of the teacher candidates found challenges in making the videos, be it working solo or in pairs, they have reflected on the whole experience in comparison to doing practical or laboratory experiments, which teachers often take for granted in particular its preparation aspect. The teacher candidates were able to adapt to the challenges of changing the science show from a live performance to a recorded video show. This format change provides an aspect of their wholeheartedness and willingness to change and the challenges that come their way, including the sudden changes to the school setting due to COVID-19. Despite the sudden challenges and changes, the teacher candidates underwent the vital process without realizing they had developed pedagogical skills.

This study also highlights the importance of reflection for new teachers to understand their potential better and learn and eventually develop their pedagogical skills and knowledge. By making the teacher candidates reflect, they are provided with the opportunity to learn and reflect upon their practices continuously. For future research, group reflection as a team could provide more insights as the shared experiences can be described collectively. Along the process, the teacher candidates have the experience of working and being connected with teammates and how they can help improve each other for a better learning experience and self-development.

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