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by

THE IMPACT OF INTERACTIVE SCIENCE SHOWS ON STUDENT'S LEARNING ACHIEVEMENT ON FIRE AND PRESSURE SCIENCE CONCEPT FOR 9th GRADER IN BRUNEI

ABSTRACT

Informal science learning (ISL) has shown considerable amount of recognition to the enrichment of science learning. The purpose of this study is to investigate one form of ISL that is on-stage shows also known as *science shows* to enhance students' achievement on fire and pressure science concepts and to investigate whether science shows could engage students in science learning. Two science shows were conducted in this study with demonstration characteristics identified as CHAMP merged with the science content development framework for science shows practiced by OGDC. In the attempt to identify whether the students 'learning achievement on fire and pressure science concept were enhanced, an experimental design research consisting of quantitative approach using pre-test and posttest achievement tests were utilized and followed by BERI protocol to measure behavioral engagement of students on science show and qualitative approach using structured interviews to elicit students' insights on the shows. Pre-test and post-test scores of the participating students were obtained and analyzed using the Wilcoxon Signed Ranked test. The test revealed a statistically significant increase in scores following participation in the pressure and fire shows, $Z = -3.562$, $p < .001$, with a large effect size ($r = 0.611$) and $Z = -3.624$, $p < .001$, with a large effect size ($r = 0.622$) respectively. Structured interview transcripts (transcribed verbatim) were obtained from six selected students that participated in the experiment whereby two themes were derived namely; knowledge gained by students and delivery of science show. The statistical and qualitative findings from the study indicated promising evidence that science shows do support students' achievement on fire and pressure concepts as well as engaging them in learning science.

Keywords: Informal science learning; Science Show; Engagement; Science Centers; Science Communicator

Introduction

Science learning takes place not only at school but also outside school such as at homes, in the museums and in the science centres. There is a strong emphasis now on exploring informal science learning in promoting students' science. Informal science learning has the potential in increasing students' motivation, engagement and interest motivation and engagement in science (Lin & Schunn, 2016; Riedinger et al., 2011). Science show as one of the informal science learning can be used in increasing students' engagement in science. Engagement is widely researched in education (Burch et al., 2015; Lane & Harris, 2015; Sinatra et al., 2015). Engagement is proven to help in the contribution of favourable learning outcomes while in school and out of school (Sinatra et al., 2015). McDonald (2016) stated that effective pedagogical practices is essential in increasing students' motivation, interest and engagement in STEM education. Educators at science centres can be called as interpreter, presenter, pilot, host, explainer, although their names differ at various location their roles remain similar (Kamolpattana et al., 2015). Educators at science centres are ensured to practice active learning approach in order to enhance engagement and interaction with the visitors, especially students. It is believed that active learning significantly improves students critical thinking skills and would trigger more interest and eagerness in learning (Hadibarata & Rubiyatno, 2019).

Science centres have been known to be established places for public learning over the past few decades. Science centres offer diverse programming and are usually offered to visitors of all ages (Falk et al., 2016). Science centres play critical role in supporting science learning by providing people with innovative and engaging science programs.

Science centres and museums have grown to be relevant in the society in enriching science concepts covered in a classroom and engaging those who are no longer part of the education system. A study by the UK Association for Science and Discovery Centres (2011) reported that 25% of 3666 first-year university students said that science centres and museums were 'important or very important' in their decision to take STEM courses. Falk et al. (2016) have identified that people who are exposed to science centres tended to have higher understanding, interest and were likely to participate in science and technology related activities than those who did not.

This study relied on research that purports to explain of the tools used by science centres to communicate science called science shows. Research on science shows indicated that science shows performed outside schools is conducted as a means to entertain audiences about science. When science shows are conducted in the science centres, the target audience is always on young children (Roche et al., 2016). Research studies such as those conducted by Baram-tsabari (2011) and Kerby et al. (2010) showed positive outcomes on primary school children's science learning and engagement. There is a need to conduct science shows not only focus on young children but also on secondary school students to ensure this group of students sustain their interest in pursuing science.

During the execution of science shows the science show presenter are tasked not only to deliver the science content effectively but also to ensure that the delivery of science is able to engage and sustain the participation of the audience (Watermeyer, 2013). This active participation reflects the success of a science show. Watermeyer(2013) states that active participation also demands that audience to be engaged and involved. The researchers suggest that the learning theory that underpins this tool is the sociocultural theory. Social mediation and cognitive development are associated with the zone of proximal development (ZPD). Vygotsky (1978) defines the ZPD as "the distance between actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p.86). Learners do not learn in isolation, students or individuals learning is enhanced with the existence of a more knowledgeable other (MKO). Communication can help student's inner and egocentric speech and eventually personal cognitive activities. Lamb and Wedell (2013) emphasized that learning takes place when the child interacts with people in his immediate environment and in cooperation with his peers and this is where the internalization processes take place. The presenters carry a persona at which students would be able to feel comfortable in interacting with them.

Numerous studies have also been focused on correlating sociocultural theory with the enhancement of teaching and learning. This includes studies trying to understand the tools that are used to promote the enactment of a ZPD (Abtahi, 2018), the role of the teacher in promoting the learner autonomy based on ZPD and imitation (Feryok, 2013) and classroom as a social plane for teachers to communicate science to students by drawing on the work and views of Vygotsky (Roslan, 2014).

This study will attempt the gap in the current research on the potential of using science shows in promoting secondary science students' knowledge and engagement in science learning. With the science show presenters as a more knowledgeable other and the type of interaction implemented during the execution of a science show, students attending the shows should be able to internalized the information learnt during a show and contributed to cognitive development amongst the students. Also, this is the first study that attempted to find out students' engagement on science shows using the BERI protocol (an instrument to measure behavioural engagement in the classroom).

Purpose of the Study

This study constitutes findings from a study conducted at a science centre called the Oil and Gas Discovery Centre (OGDC) in Brunei. The study focuses on finding the impact of conducting science shows for their student visitors of year nine (secondary science students age between 15-16 years old). As mentioned earlier, previous research conducted on science centres are often focussed on young children rather than this group of secondary school students. The motivation behind this study was the evident positive reactions that the researchers can see as students watch, participate or engage in a science show. From the observations made, the researcher decided to investigate further the impact that a science show has on students' understanding of science concept delivered and their engagement in learning those concepts. In this study, two science topics were chosen, the fire show and the pressure show. These two topics were chosen due to the notoriety of these topics being difficult for students to understand.

This has driven the researcher to develop two research questions, namely (1) do science shows enhance students' learning achievement on fire and pressure science concepts? and (2) do science shows engage students in learning science?

Informal science learning in promoting students' engagement

According to an informal science learning review carried out by the Wellcome Trust in 2012 (Triyarat, 2017), informal science learning is non-compulsory or free choice learning which takes place outside of the formal curriculum. However, informal science learning can reinforce formal education. The informal science learning can be referred to activities that occur outside of the school setting, not deployed specifically for school use and it may include activities in the media (TV, radio, and film) in designed settings such as museums and science centres, botanical gardens, zoos and aquarium, gaming and cyber learning, school outreach programs and youth community (Alabdulkareem, 2015; Stocklmayer et al., 2010) The informal experiences provided by informal science learning help to complement and extend students' learning opportunities beyond those available in school (Reiss et al., 2016; Russell et al., 2013). Informal science learning has been gaining in attention as it promotes students understanding of scientific concepts and natural phenomena (Battrawi & Muhtaseb, 2013).

Informal science learning is often divided into four activities in an informal setting, which include shows on stage, experiments or laboratories, hands-on exhibits and games (Triyarat, 2017). The focus of this study is the shows on stage which is also called science shows. Science show is one form of science communication that categorises in the informal science learning (ISL) group where it uses performance inclusive of elements such as dramatic gestures, actions and demonstrations in order to engage with the audience; it is sometimes referred to as science theatre or lecture demonstrations (Walker, 2012).

Understanding science shows

Science shows started in the late 17th century at the Royal Society in London, whereby public lectures on Newtonian mechanics were delivered by John Keill (Taylor, 1988). More work on science shows was emphasised during the 19th Century of Sir Humphry Davy, and his successor at the Royal Institution, Michael Faraday. Science show presenters, also known as science communicators at different science centres, have a similar role to that of teachers with additional characters, such as the need to connect with students or audience, the use of demonstrations, the desire to motivate and most importantly to engage and enhanced students understanding. They are encouraged to interact with the student audience by frequently asking provoking questions during the shows as questioning may help in promoting students' thinking and their understanding of science concept (Roslan et al., 2018). By having the students answering to the questions of the science communicator it provides a two way communication whereby at every attempt to answer a question asked during a show, science communicator is able to give immediate feedback to every response received. Feedback process provides students with opportunities to be engaged in a constructive dialogue with the educator in this case the science communicator (Abdurrahman et al., 2018).

The pedagogical approaches implemented by educators play a significant role in students' motivation in STEM engagement (Mcdonald, 2016). Science show is about communicating while showing. A science show cannot teach unless the science communicator can sustain the audience attention; therefore, the science show needs to be entertaining (Kerby et al., 2010). In the views of Watermeyer (2013) science show is a series of interactions whereby it is not evident to the learner as learning or focused on the production of learning outcomes. However, it is a learning process where learning is tactic and positive learning outcomes are unexpected, and the learner is not interrogated for the extent of his/her learning. Science shows aim to stimulate participants' interest in science and technology through emphasising their importance, ensuring that the scientific phenomena are linked to everyday life and experiments presented on stage are to excite and amaze the audience.

Science show demo categories

Sadler(2017) recommended several demo categories that can be implemented in the delivery of a science show, as there is evidence that suggests different types of the audience respond to different categories. These demo categories are curiosity, human, mechanics, analogy and phenomena (CHAMP). Human demo category uses volunteers to enhance audience interaction. Analogy demo category uses visual aids in order to represent something that is usually invisible to make the audience better understand whereas the mechanics and phenomena demo category involve science application in real life things and a chance to see a scientific phenomenon happening live that may make use of equipment not readily available. These demo categories were implemented during the execution of the science shows for this study. Another characteristic that makes a science show unique is the fact that they are often conducted by science communicators of various backgrounds, containing content which is mostly real-life application however interlinking with the school syllabus. Most shows would make use of self-made materials and demonstration items, which range from highly flammable materials to materials which can be easily found in the kitchen. The rationale behind the meticulous approach to communicating science in a science show is to ensure the emotional connection and engagement between the science communicator and the student audience.

To supplement the CHAMP demo categories the shows were developed in accordance to the framework developed by the centre itself that covers how the science is delivered in a science show. This framework aims to ensure that the science concept delivered in science shows would be well received by students experiencing the shows. The framework utilised in the science shows delivered by OGDC is as stated in table 1 below.

Table 1 Framework for the development of science content in science shows

Action	Description
Short and simple	The science explanations are made simple. The role of the science communicator is to communicate clearly and not communicate lots.
Step by step	The science concepts are delivered in a stepwise logical way. New information is added onto what the science communicator has already explained or what people already know.
Adding complexity	Complexity is added in accordance to audience's age group. The younger the audience the simpler the science is made.
Reiterating key ideas	Key ideas or science concepts in the shows are repeated regularly and at different angles in the demo.
Effective questioning	Reiterating key ideas above can be achieve through effective questioning and this usually involves guiding questions.
Using analogies	Analogies can be used to make understanding of difficult terms or concepts easier.
Body Gestures	Body gestures can be utilised as visuals to explain scientific concept that can't be seen in demos. Eg. Particles getting squashed due to high pressure.

The combination of the two frameworks was predicted to be able to enhance the delivery of the science shows at the centre. These frameworks did not only consider how the demos were delivered, but how the science content was built. This gave a holistic approach to how science shows were developed at OGDC. The comprehensive approach aimed to be able to enhance students' understanding of scientific concept delivered in the shows and ensuring that the students were fully engaged.

The role of engagement in learning science

Low engagement in learning has been related to problems such as low achievement and increasing dropout rates in schools (Sinatra et al., 2015). Learning science has been a significant challenge for students; science is perceived to be difficult and is minimally engaged in learning it (Ateh & Charpentier, 2014). Student engagement is enabled or supported by multiple factors (Godec et al., 2018). External factors include the nature of family and peer support (Bempechat & Shernoff, 2012) and the role of their educators and their teaching approach to interact with students (Pianta et al., 2012; Roorda et al., 2011). According to Godec et al. (2018) understanding the importance of the roles played by the multiple factors are crucial as student engagement is a dynamic and cyclical process in which positive engagement is likely to encourage further engagement in learning by the learners. Lawson and Lawson (2013) further stated that lack of engagement will likely deter students from getting engaged in learning in the future.

Methods

In order to achieve the solution to the research question one an experimental design approach was conducted whereby the researcher applied the pre and posttest design. Creswell (2012) states that a pre-test provides a measure on some attributes or characteristics that will be assessed for participants in an experiment before they receive a treatment. Meanwhile, a posttest is a measure on some attributes or characteristic that will be assessed for participants in an experiment after a treatment. Whereas the solution for research question two was determined by conducting an observation tool called the BERI protocol followed by student interview.

The researchers developed a sequence for the data collection, which were used throughout the data collection process. The simplification of the sequence is presented in figure 1 below.

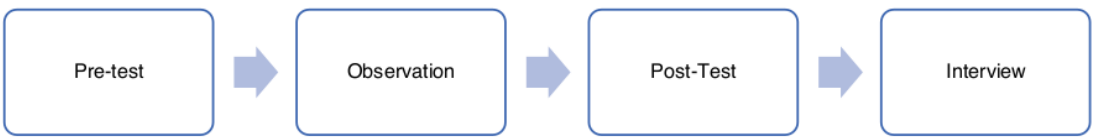


Figure 1 Data collection sequence for the study

Participants of the study

The participants of the study consisted of 17 students altogether, of which 10 of them were male students of year nine at a government school in the Belait District (one of the four districts in Brunei). Table 2 below contains the descriptive statistics of participating students. Majority of the students has Malay (the national language of Brunei) as their first language with mixed abilities. However, students in Brunei learn most of their significant subjects such as Maths and Science in English. In this study, science shows were conducted in English.

Table 2 Descriptive statistics of participating students

	Frequency	Percent	Valid Percent	Cumulative Percent
Male	10	58.8	58.8	58.8
Female	7	41.2	41.2	100.0
Total	17	100.0	100.0	

Both science shows consisted of 8 to 10 demonstrations which took approximately 40 minutes to an hour of delivery time. The pressure show covered topics such as force and the Bernoulli Principle; topics found in the year nine syllabus of the physics subject (Cambridge Curriculum, Cambridge Assessment International Education, n.d.). The fire show had eight demonstrations altogether that touched profoundly on the fire triangle topic. This topic was correlated with the acids, base and salts chemistry topic in the syllabus (Cambridge Curriculum, Cambridge Assessment International Education, n.d.).

For this study, the researchers adhered to the process required prior to conducting the experiments on the students. Permission was first obtained from the Department of Schools, Ministry of Education. Followed by a discussion with the principal of the participating school. The researchers provided the principal of the participating school detailed description of the procedure that took place in the study. This was so that the principal and teacher in charge would have full disclosure of the potential risk to the students and sites in the study (Creswell, 2012). Participants were ensured that pseudonyms were assigned to individuals and school names. Detailed program and duration of the time the students would spend on science shows were made clear with the school simultaneously, all test questions and interview questions were shared so that the principal and teacher in charge were aware of the what the questions were and the sensitivity of the interview questions asked. Informed consent was also obtained from all participants. The execution of the science shows took place at the centre itself. The students were invited to the theatre of OGDC where most science shows were conducted at the centre.

Research instrument

Pre and post test questions were given out to investigate students' understanding of the scientific concepts presented in the shows. This reflects the students learning achievement on fire and pressure science concepts. The questions to the pre and posttest were similar and contained scientific concepts which were found in the science shows. The test questions were divided into two sections; a set of multiple choice questions and structured questions. The questions on pressure and fire comprised of 6 multiple choice and 6 structured questions and 7 multiple choice and 7 structured questions respectively. The developed items matched with the learning objective identified in the Cambridge GCE O level which is a renowned examination institution based in the United Kingdom. The test questions were also reviewed by another researcher for content validity.

Structured interviews were then conducted on six selected students that participated in the experiment which were then transcribed verbatim. Two students were interviewed at a time. Students were selected based on the marks obtained from the test after the shows were conducted. The students consisted of two top, average and lowest scoring students respectively. The interview served three purposes. First, it was to elicit the students' ideas or perceptions on using science show as a learning tool. Second, it was used to identify weather science shows were really engaging for the students. Third, the interview was used to validate and ensure the questions asked and method used was relevant. To further support the findings from the interview, quantitative analysis using BERI protocol (Lane & Harris, 2015) was also implemented. To enhance the validity of the data collected using the BERI protocol, two observers were selected to do an observation on selected students as they witnessed the shows. Prior to the observation session, a briefing was done by one the researchers with the observers to ensure that the process was clear.

Data Collection

Upon approval, one of the researchers went into the school to run the data collection by first conducting the pre-test. Both test questions lasted 30 minutes each. Two weeks after the pre-test session, the students attended the science shows which took place at OGDC itself. Both pressure and fire shows were performed by one of the researchers who was an experienced science show presenter. Each show took approximately 45 minutes each. The pressure show took place first as soon as the show ended, students were given 10 minutes to freshen up and get themselves ready to undergo the post test. Soon after the pressure test was done, the students were given an hour break for lunch. The session then continued on with the fire show followed by the post test on fire.

Whilst the shows were conducted the BERI protocol was also implemented. The main aim of the BERI protocol was to quantify the number of students who were engaged during the shows. During this study, the protocol was modified to better suit the situation of the shows. The BERI protocol can be used to provide timely feedback to instructors as to how they can improve student engagement in their classrooms and was originally designed for university student behavioural engagement which was defined as on-task behaviour in the classroom (Lane & Harris, 2015). Observation data within single class periods, within a single course over multiple class periods, and across multiple courses were conducted to ensure the validity of BERI (Lane & Harris, 2015).No study has been identified to date to use such protocol specifically for the study of behavioural impact from science shows. The observation protocol uses simple coding system that would be quick and easy for observers to learn that could be easily presented to the instructor or lecturer. Behavioural reactions from shows were identified and agreed between the researchers and observers, whom were science show performers themselves, to be defined as engaged and disengaged during a science show. Table 3 below contains the classification of student behaviours to indicate they are engaged.

Table 3 Description of student behaviours to indicate they are engaged

Engagement Code	Behaviours to indicate students are engaged
E1	Laughter
E2	Facial Expression -Interested / Excited - Curious / Focused
E3	Clapping of Hands
E4	Attentive
E5	Volunteer
E6	Answers questions asked

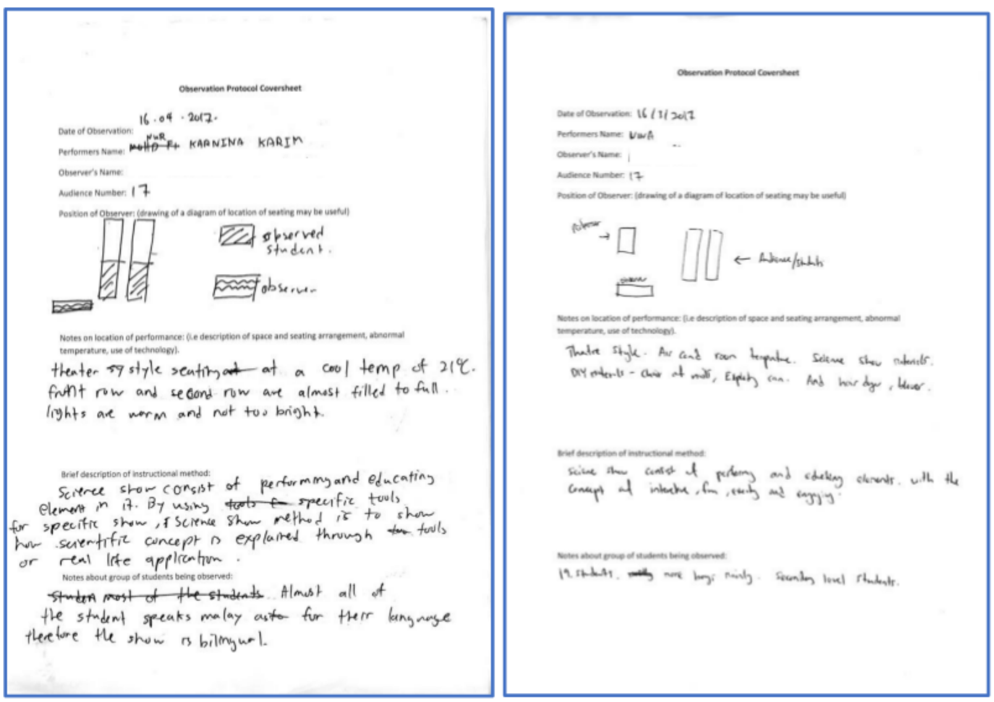
E7	Active body language
E8	Coming to talk after the show to ask questions

Table 4 below contains the classification of the student behaviours to indicate they are disengaged during the shows.

Table 4 Description of student behaviours to indicate they are disengaged

Disengagement Code	Behaviours to indicate students are engaged
D1	Unresponsive -Bored -Uninterested
D2	Distracted by surroundings instead
D3	No facial expression
D4	Does not answer any questions asked

These behaviors did not guarantee that a student was engaged or disengaged, however these were a set of pronounced behaviors, which were agreed between the observers and the researchers. Just like in the literature prior to the execution of the show observation, the observers were first briefed on what were the shows that were going to be conducted and the notes containing the science content of the shows together with the flow of the demonstrations that were going to be performed were shared with them. At the beginning of the show the observers were asked to fill in a cover sheet, which contained the following information as shown in figure 2.


Observation Protocol Coversheet

Date of Observation: 16 . 04 . 2017.

Performers Name: ~~MOHD F.~~ NUR KARNINA KARIM

Observer's Name:

Audience Number: 17

Position of Observer: (drawing of a diagram of location of seating may be useful)

observed student.

observer

Notes on location of performance: (i.e description of space and seating arrangement, abnormal temperature, use of technology).

theater style seating ~~at~~ at a cool temp of 21°C. front row and second row are almost filled to full. lights are warm and not too bright.

Brief description of instructional method:

Science show consist of performing and educating element in it. By using ~~tools f~~ specific tools for specific show, of science show method is to show how scientific concept is explained through ~~the~~ tools or real life application.

Notes about group of students being observed:

~~Student most of the students~~ Almost all of the student speaks malay ~~as~~ for their language therefore the show is bilingual.

Observation Protocol Coversheet

Date of Observation: 16 / 3 / 2017

Performers Name: NWA

Observer's Name:

Audience Number: 17

Position of Observer: (drawing of a diagram of location of seating may be useful)

Notes on location of performance: (i.e description of space and seating arrangement, abnormal temperature, use of technology).

Theatre Style. Air cond room temperature. Science show materials. [illegible]

Brief description of instructional method:

Science show consist of performing and educating elements. with the concepts of interactive, fun, [illegible] and engaging.

Notes about group of students being observed:

19 students. [illegible] more boys [illegible]. Secondary level students.

Figure 2 Coversheet for the observers

Once the show started, observation points were recorded directly onto the copy of the science show notes given during the first briefing between the researcher and observers, in the section corresponding to what was being performed. This is to ensure that the observers were able to relate engagement with what was happening during the show. According to Lane and Harris (2015) an observation point were to be taken for every page of notes, for any major change in activity or content, or at 2-minute intervals depending on which time interval was shorter. An adjustment was made to the intervals of observation during the observation session in this study to best suit the science show format. Changes in students' reactions were recorded during the change of each demonstration. Students' interactions with the performer were also observed which included their behaviors and questions that were not pre-planned. For the BERI protocol observation ten students that participated in the experiment were chosen according to the scores on the pre-test. The group of ten students were a mixture of low, average and highest scoring students. The two selected observers were seated at a location where they were able to see all ten students clearly. Soon after the post-test on fire was completed, interviews with six selected students took place and were conducted by one of the researchers. From there, students' interviews were transcribed verbatim and thematic analysis was used to discuss the students' responses. During this study students' interviews were analysed manually using thematic analysis to elicit overarching patterns and themes.

Data analysis

First step to the analysis of the test scores were assessing for normality. Since the data were not normally distributed, the pre-test and post test scores were analysed using the Wilcoxon Signed Ranked test. The Wilcoxon Signed Rank Test is designed for use of repeated measures meaning participants are measured on two occasions (Pallant, 2013). Students' interviews were transcribed verbatim and thematic analysis was used to find the emerging themes of the study. Thematic analysis was implemented due to its flexibility. The flexibility of the thematic analysis can be used to answer almost any type of research question at which the themes can be identified in a data-driven, bottom-up way or identified in a more top-down fashion (Merriam & Tisdell, 2015). The researchers had several expected themes to look for during the thematic analysis and simultaneously kept an open mind for new emerging themes. Thematic analysis often combined two approaches in one analysis. The procedure in the thematic analysis for this study involved getting familiar with the data, coding, searching for themes, reviewing the themes, defining and naming the themes. Thorough peer examination involved asking a colleague to scan some of the raw data and assess whether the findings were plausible, based on the data (Merriam & Tisdell, 2015). Through the implementation of the BERI protocol, the researchers were able to accumulate the total number of students that were engaged and disengaged when a demonstration was implemented during the observation session through the calculation indication made by the observers.

Results and Discussion

The data presented in Table 5 below were extracted from the pre and post tests conducted for the year nine students. The table 5 below carries the overall mean scores and standard deviation from the pre and post tests for the pressure and fire show.

Table 5 Overall mean score and standard deviation of pre and post tests

		N	Mean	Std. Deviation
Pair 1	Score on test before pressure show	17	4.9412	1.71284
	Score on test after pressure show	17	7.9118	1.80481
Pair 2	Score on test before fire show	17	9.4412	2.92555
	Score on test after fire show	17	15.0882	2.34678

As shown in Table 5, the post-test overall means score of both shows is higher (7.91 for pressure show and 15.1 for fire show) compared to pre-tests overall means score. The difference is 2.97 for the pressure show and 5.66 for the fire show. To find out whether the difference between the pre and post-tests overall mean scores are statistically significant, a Wilcoxon Signed Rank Test was performed using SPSS software version 21.

Prior to conducting the analysis data were first checked for normality. Due to the existence of outliers and also having a sample of 17 students only, this further supports the usage of the Wilcoxon Signed Rank test. From the test that was conducted post-test ranks were statistically higher than the pre-test ranks for both the pressure and fire show. Whereby Z= -3.562 and -3.626 respectively and P values for both shows is .000. as shown in Table 6 below

Table 6 Wilcoxon Signed Rank test result for pre and post tests

	Test Statistics^{a}	
	Score on test after pressure show – score on test before pressure show	Score on test after fire show – score on test before fire show
Z	-3.562^{b}	-3.626^{b}
Asymp. Sig. (2-tailed)	.000	.000

From the pre and post test quantitative analysis it showed that there is a significant increase of improvement in students marks. This revealed that after the science show performance, students gained understanding of the science concept that were performed by the researcher. Such result is consistent with previous findings by previous studies (Baram-tsabari, 2011; Kerby et al., 2010) although the age group for this study were mainly focused on year 9 students and the science concepts covered in the show were science topics which were known to be challenging for the students.

Findings from BERI Protocol

Through the utilisation of the BERI protocol, the observers were able to identify whether students were engaged and at which occasion they were engaged the most. Using tables 3 and 4 to quantify the number of students' engagement, the observers recorded how many out of the ten students were engaged and disengaged. The observers were also able to identify in which category of behavioural description the students belonged at. The results were written against the notes given to the observers at which have been compiled in tables 7 and 8 below. Table 7 below indicates the number of students engaged and which part of the behavioural engagement was shown during the pressure show.

Table 7 Observations noted during the Pressure show

Action	Number of Students Engaged	Behavioural Observation
Name of Demo: Chair of Nails		
Fruit on nails demonstration	10	During the whole demonstration the behavioural engagement observed range from E1 to E7. Students were engaged and responsive, this includes them asking questions and answering questions asked
Students were asked to feel the nails		Female students were quieter whereas the male students showed a more active body language
Sitting on nails demonstration		Students were engaged and responsive, this includes them asking questions and answering questions asked
		Although some were shy when asked to volunteer
Performer explained about pressure		
Name of Demo: Air Rocket		
A student was asked to launch the rocket	8-9	During the whole demonstration the behavioural engagement observed range from E1 to E7 Students became more excited when they saw the rocket demonstration Female students were still less verbal than the male students One of the male students was reluctant to volunteer Students responded with questions Students were showing active body language and verbal comments
An explanation followed right after		Three male students showed D1 behaviour when explanation part was taking place
Name of Demo: Bernoulli Bag		
Two students were asked to come forward	9	During the whole demonstration the behavioural engagement observed range from E1 to E7
Performer demonstrated how to blow into the bag		Female students started to get comfortable and showed more active body language and getting more verbal
Students were given an opportunity to try and blow into the bag		A female student successfully stated the concept of the demonstration
		Two male students were showing D2 behaviour while the demonstrations were taking place
Explanation comes after		

Name of Demo: Hair Dryer with Balloon		
Performer showed students how a balloon floats when blown with a hair dryer	10	During the whole demonstration the behavioural engagement observed range from E1 to E7 Female student volunteered the moment called to the stage
Name of Demo: Beach Ball with Leaf Blower		
Performer made a comparison between the previous demonstration and the ongoing demonstration Student was asked to the stage to run demonstration Explanation comes after	9-10	During the whole demonstration the behavioural engagement observed range from E1 to E7 Students were listening attentively during explanation One female student showed D1 behaviour
Name of Demo: Bazooka Vacuum		
Students were surprise with a vacuum Two students were called to participate in the demonstration Explanation comes after	10	During the whole demonstration the behavioural engagement observed range from E1 to E7 Two male students that were asked to volunteer were reluctant to go to the stage When explanation was ongoing students were attentive, they seemed excited and were leaning towards the front
Name of Demo: CO_2 Canister		
Performer started off the demonstration by mixing Panadol and vinegar Students were shown the reaction Questions were asked to students Explanation comes after	10	During the whole demonstration the behavioural engagement observed range from E1 to E7. Students were still a bit shy
Name of Demo: Exploding Can		
Performer started the demonstration Explanation comes after	10	During the whole demonstration the behavioural engagement observed range from E1 to E7

Table 8 below indicates the number of students engaged and which part of the behavioural engagement was shown during the fire show.

Table 8 Observations noted during the Fire show

Action	**Number of Students Engaged**	**Behavioural Observation**
Name of Demo: Chalk Methanol		
Performer asked what is needed for fire to continue lighting up?	8-9	During the whole demonstration, the behavioural engagement observed range from E1 to E7

Performer showed chalk and explain the characteristic of chalk		Student showed expression of interest Students were able to answer questions successfully
Performer explained the experiment		Some students showed D1, D3 and D4 behaviours during the explanation part of the demonstration.
Name of Demo: Bicarb Soda Experiment		
Performer started off with explaining about the acid, base and neutralization The CO_2 gas that was formed from the experiment were shown to students	7-8	During the whole demonstration the behavioural engagement observed range from E2 to E7 A student got his attention back on the show Students managed to answer questions asked
A full explanation of the demonstration was then delivered to the students		Some students showed D1 and D3 behavioural response after demonstration is done
Name of Demo: Stuck like Glue		
This interesting demonstration started off with the performer asking the students what were the materials that were available that was able to lift a plate without the performer having direct hand contact on the plate Full demonstration then took place	10	During the whole demonstration the behavioural engagement observed range from E2 to E7
It was then concluded with an explanation of the science behind the demonstration		Students started to be attentive during the explanation of the science behind the demonstration
Name of Demo: OGDC Cannon		
The demonstration started off with the performer showing the students OGDC's self-made cannon which is made out of a drinking bottle	9	During the whole demonstration the behavioural engagement observed range from E1 to E7
To make this demonstration more exciting was the *Angry Bird* (cartoon character) prop used as bullets		Students were seen to discuss about the demonstration amongst them
It was then concluded with an explanation of the science behind the demonstration		Some students showed D1, D2 and D4 behaviours.
Name of Demonstration: Fire Rocket		
This demonstration was started off with introducing OGDC's rocket, which is actually just a plastic coke bottle	9-10	During the whole demonstration the behavioural engagement observed range from E1 to E7
The demonstration includes launching the bottle using methanol as fuel and a lighter as the activation energy		Students were excited Some responded slowly when questions were asked but still tried to answer

It was then concluded with an explanation of the science behind the demonstration		
Name of Demo: Fire Tornado		
This demonstration uses a rotating disk to create a circular motion It involves the use of methanol as fuel and a mesh as a cylindrical cover to behave as trees It was then concluded with an explanation of the science behind the demonstration	7-8	During the whole demonstration the behavioural engagement observed range from E1 to E7 Two students were seen to be discussing about the demonstration Students were seen to amazed with the demonstration
Name of Demo: Swoosh Bottle		
During this demonstration students observed the strength of two different fuels Two fuels used were methanol and rubbing alcohol Both fuels were poured in to two different glass bottles and were burnt	10	During the whole demonstration the behavioural engagement observed range from E1 to E6 Students were amazed with the demonstration Students started slowly to be inactive. Students started slowly to be inactive. Sleepy faces started to appear.
Name of Demo: Hands on Fire		
Performer started off with asking if they would like to see her setting her own hand on fire Performer then started to mix all of the ingredients together Performer showed how the demonstration took place and invited another science communicator to assist in the demonstration It was then concluded with an explanation of the science behind the demonstration	10	During the whole demonstration, the behavioural engagement observed range from E2 to E7 Three male students were seen discussing excitedly about the demonstration Some students were familiar with the demonstration

The BERI protocol showed that during the majority of the demonstrations, all ten students were engaged, and the least number of engaged students was seven on average. Apart from this data, i.e. the number of students engaged, the researchers also observed that students' engagement could be sustain when science shows were not stretched to more than 45 minutes in duration. The limitation of this data was the fact that the time at which each demonstration and explanation took place was not recorded. Hence, the exact timing for the engaged and disengaged behaviours of students' occurrence was not recorded. The BERI protocol may not be able to identify cognitive interaction just like what was stated in Lane and Harris (2015), however this gap has been overcome through the qualitative findings obtained from the interview. This has shown the triangulation approach has been proven to be an effective approach in achieving comprehensive analysis in obtaining reliable and plausible result in this study.

Collective findings from thematic analysis

For the qualitative data, two main themes emerged. The two identified themes were knowledge gained by students and delivery of science show. The main aim for qualitative data analysis was to further enhance the quantitative findings and further determine how the students were able to understand the science concept delivered in the shows simultaneously examining students' engagement during the shows. During the execution of the shows, it was ensured that the five science demonstration categories (CHAMP) identified by (Sadler, 2017) were implemented in the shows whenever appropriate. Study made by (Sadler, 2017) was mainly to identify how much the viewers of the science show were able to recall the demonstrations delivered. This study brings it a step further by identifying whether students were able to recall the scientific concepts delivered in the show potentially because the shows were engaging.

The summary of the overarching themes and patterns that appear from the interview data is presented in figure 3 below.

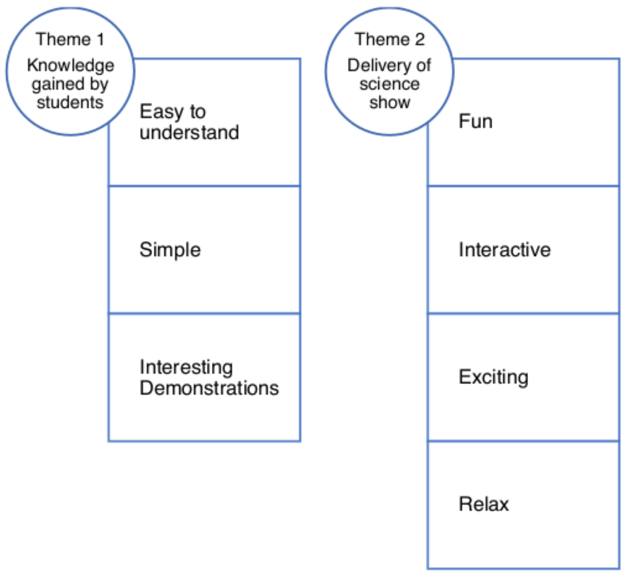


Figure 3 Themes or categories elicited from interviews

Theme 1: Knowledge Gained by Students

The shows performed seemed to teach the science concept presented during the shows. The interview questions asked investigated students' insights into the shows presented and the amount of information that they were able to recall from the show. The first theme that emerged from the students' responses to the interviews was *knowledge gaining*. This theme derived from the statements given by the students. When asked what do the students feel about the science show performances the year nine students said:

Lan: Uh, it is excellent, ok lah, uh, mudah difahami *(easy to understand)*

Halim: Macam topicnya (*like the topic*), macam sebelum atu ahh kami buat test atu disekolah payah kan jawap lah (*when we did the test at school it was really hard for us to answer the questions) *test here refers to the pre-test questions.* Kalau lapas science show atu kami buat test atu ok (*after the science show when we did the test it was okay*) **test here refers to the post-test*

Fatin: Good.

Researcher: It was good for you? Why do you feel it's good?

Fatin: Because it was easy to understand.

Knowledge was quickly gained since the content of the science shows were easy to understand. To ensure that the science concepts were easily understood during the shows, the science concept presented was made as simple as possible incorporated with exciting demonstrations. This goes back to the strategy mentioned in the framework practiced by OGDC and merging it with the demo characteristics advocated by Sadler. Not only those demonstrations were proven to be able to make students understand better, but demonstrations were also found to be interesting for the students, and this was accumulated as well during the interview. It was also observed that the "bigger" the demonstrations the more the students found it interesting and exciting. This goes back to the step-by-step approach of the science content. The researcher further asked the students what made them like science shows. Lan, Qillah, Fatin and Amal, went straight to mention about the demonstration that they saw in the shows.

Researcher: Lan what do you like most about the show?

Lan: (Grins) Experimentnya *(the experiments).*

Researcher: How about you Qillah? What do you feel, what can you comment on the show just now?

Qillah: Ermm actually most of the demonstrations just tu *aa*, its new. I've never seen at all many of them before, it's quite interesting both pressure and fire.

Fatin highlighted in the interview what she liked about the show was the fire rocket demonstration and the hands-on fire. In contrast, Amal liked all the demonstrations in the fire show and highlighted his personal favourite demonstration from the pressure show was the OGDC cannon. From the data itself, it showed that students not only found the content of the shows easy, they remember which demonstration they liked the most, and they found the shows interesting. The hands-on fire seemed to be the most liked demonstration. From the title itself, it does automatically spark curiosity. This supports the findings from Sadler's study whereby it was mentioned that curiosity type demo is proven to be universally popular regardless of audience and were able to reflect high impact rate for short and long-term recall.

The data showed that the demonstrations do play a significant role in science shows. From the open codes above the researcher concluded that after analytical coding, the knowledge-gaining category could be elicited and this finding is represented in Figure 4. This finding again supports research question 2. Do science shows enhance students understanding?

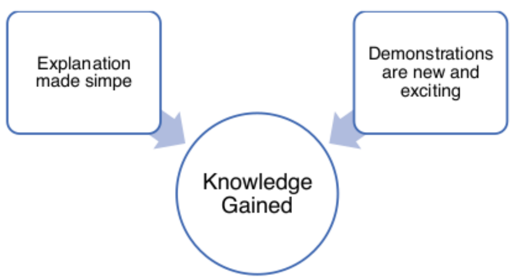


Figure 4 Theme 1 derived from data

Theme 2: Delivery of science show

It was then asked during the interview why did they like the science shows in order to find out what were the students' perception towards the science show apart from just the data obtained above. With that, another category emerged from the analysis. The excerpt below contains some of the responses of the students about their emotions and responses to the two science shows that were conducted.

Researcher: What do you feel different between science show and normal lesson yang kamu selalu ada di sekolah (*that you always have in school*)?

Lan: Lesson serious sikit (*abit*), science show ada main main lagi (*there is play time*).

Researcher: Apa tu (*what do you mean*)?

Lan: Science Show ada main main lagi (*there is abit of a play), serious lesson, serious*

Sofian: Sama (*same for me*)

Halim: Kalau (*if*) normal lesson, macam (*like*), nda banyak ia punya (*not a lot of*) demonstration, kalau (*if*) science show banyak ia punya *(there are a lot of*) demonstration.

Qillah: If normal classes it's too formal, but for sciences show its interesting pasal ada (*because there are*) activities apa and all that.

Researcher: Do you feel macam (*like*), apa nie *(what is it*), how should I put this ah. Kalau (*if*) you go to the math class atu you have to be more focus, kalau (*if*) di science show atu tadi (*just now*) nda(*don't need to be*) focus?

Fatin: Focus tapi (but), fun.

Researcher: Ahh... fun. More fun for you?

Fatin: Nods. Nda ngantuk (*doesn't make me sleepy*).

Researcher: Nda ngantuk (*not sleepy*). Ahh ok. How about for you? Apa bezanya (*what's the difference between*) normal lesson sama dengan (*and*) science show?

Amal: Kalau (*if*) normal lesson... kadang kadang boleh tertidur (*sometimes you can fall asleep*)

Researcher: Boleh tertidur (*you can fall asleep*)? Okay.

Amal: Kalau macam (if a science show) science show ani (*like this*), excited.

It was concluded from the analysis that key factors that engage the students during the shows were the fact that during the shows, students were excited, they were relaxed and there were times when the show itself turns playful and what kept them going was the fact that they were also interactive. Lan mentioned that the difference between a regular classroom lesson and a science show was that, while attending a science show they felt relax, it was less serious. It gave them a window of 'playtime' and his statements were supported by Sofian. The researcher has rephrased the word playtime in this context as able to interact or interactive. Fatin mentioned that they were focused, but they had fun too, and Amal added to Fatin's comment by saying that the science shows made her feel excited. The theme drawn out from the data is the delivery of a science show, and this finding is represented in Figure 5.

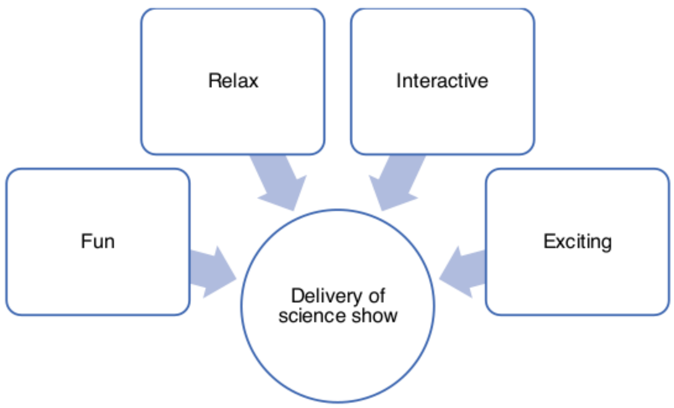


Figure 5 Theme 2 derived from data

Conclusion

The findings from the analysis have shown that science shows are not only effective in enhancing students' learning achievement of certain science concept of interest it is also able to engage students while they attend the shows. The combination of CHAMP demonstration characteristics and the science content development framework used by OGDC can be merged for the development of an effective science show. This is evident through the findings obtained that the science shows were able to enhance students' knowledge due to the simplicity of science content and the interesting demonstrations included in the shows. This has resulted that when students participate in a science show session, they were able to interact with the performer and they enjoyed themselves when they attended the science show sessions. Through the social interaction during a science show and the presence of science communicator as a more knowledgeable other the students were able to internalize complex problems. Given the notoriety of the topics discussed during the shows being difficult for students to understand, science shows were proven to be able to enhance students learning achievement and this was reflected in the pre and post-tests. Not only that, students were also engaged and entertained during the science show sessions and engagement is an important essence to ensure a favourable learning outcome. This was reflected during the observation session using the BERI protocol is also crucial that the shows are performed in an environment which is safe and relaxing for the students, this is to accentuate the playful and enjoyable dimensions of science as it may be enlisted to facilitate innovative thinking, experimentation, risk-taking and reflective thinking, all requisite qualities of learning citizen (Watermeyer, 2013). This study has shown the potential of using science shows in promoting secondary science students' knowledge and engagement to learn difficult topics such as fire and pressure.

Science show can be used to create new forms of engagement and participation not just for students but the general public of all ages (Carpineti et al., 2011). Informal science learning reflects the growing recognition that it plays a significant role in education. Communicating science needs to be made exciting and engaging to enable its viewers and listeners to build an emotional connection to the topics delivered. Connection attracts attention and attention attracts learning. Other teaching approaches are needed in order to support student competency for facing the changing world (Ngabekti et al., 2019) and one of the approach is by utilizing science shows. Science shows can be used as a powerful tool to communicate the importance of contemporary debates about science and technology.

This study has shown that science shows can facilitate learning. Although adaptable, there are still challenges in conducting science shows. The lead-time in science shows may be a turn off for teachers to conduct science shows during lessons. The rigidity of the school syllabus and the exam-oriented system may result in the hesitance of conducting science shows during lessons due to time constraint and the importance of finishing the syllabus before the exams. Whatever the challenges maybe the impact that the science show brings 1 can outweigh the drawbacks of the preparation of science shows. Delivering a narrative of science that will stimulate young learners' interest and enthusiasm, requires not only a strong sentiment for science and competency in delivering it, but a continuous investment in building and bettering communicative capacities (Watermeyer, 2013). With the clear-cut guidelines such as the CHAMP demonstration categories and the science content development framework by OGDC, the development of science shows can easily be transferred to science teachers. To make every preparation of science shows more beneficial, content of science shows can be made to focus on specific science content highly related to the syllabus just like the ones used in this study.

12

References

Abdurrahman, A., Saregar, A., & Umam, R. (2018). The effect of feedback as soft scaffolding on ongoing assessment toward the quantum physics concept mastery of the prospective physics teachers. *Jurnal Pendidikan IPA Indonesia*, *7*(1), 34–40.

17 Abtahi, Y. (2018). Pupils, tools and the Zone of Proximal Development. *Research in Mathematics Education*, *20*(1), 1–13.

22 Alabdulkareem, S. A. (2015). Exploring the Use and the Impacts of Social Media on Teaching and Learning Science in

Saudi. *Procedia - Social and Behavioral Sciences*, *182*, 213–224.
Ateh, C. M., & Charpentier, A. (2014). Sustaining Student Engagement in Learning Science. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *87*(6), 259–263.
Baram-tsabari, R. P. A. (2011). *Atom Surprise : Using Theatre in Primary Science Education*. *April*, 508–524.
Battrawi, B., & Muhtaseb, R. (2013). *The Use of Social Networks as a Tool to Increase Interest in Science and Science Literacy : A Case Study of ' Creative Minds ' Facebook Page*. *March 2013*.
Bempechat, J., & Shernoff, D. J. (2012). Parental influences on achievement motivation and student engagement. In *Handbook of research on student engagement* (pp. 315–342). Springer.
Burch, G. F., Heller, N. A., Burch, J. J., Freed, R., & Steed, S. A. (2015). Student Engagement: Developing a Conceptual Framework and Survey Instrument. *Journal of Education for Business*, *90*(4), 224–229.
Cambridge Assessment International Education. (n.d.). Cambrige curriculum: Physics. Retrieved from https://www.cambridgeinternational.org/programmes-and-qualifications/cambridge-o-level-physics-5054/
Cambridge Assessment International Education. (n.d.). Cambrige curriculum:Chemistry. Retrieved fromhttps://www.cambridgeinternational.org/programmes-and-qualifications/cambridge-o-level-chemistry-5070/
Carpineti, M., Cavinato, M., Giliberti, M., Ludwig, N., & Perini, L. (2011). Theatre to motivate the study of physics. *Journal of Science Communication*, *10*(1), 1–10.
Creswell, J. W. (2012). Educational research: Planning, conducting, and evaluating quantitative and qualitative research. In *Educational Research* (Vol. 4).
Falk, J. H., Dierking, L. D., Swanger, L. P., Staus, N., Back, M., Barriault, C., Catalao, C., Chambers, C., Chew, L. L., Dahl, S. A., Falla, S., Gorecki, B., Lau, T. C., Lloyd, A., Martin, J., Santer, J., Singer, S., Solli, A., Trepanier, G., … Verheyden, P. (2016). Correlating Science Center Use With Adult Science Literacy: An International, Cross-Institutional Study. *Science Education*, *100*(5), 849–876.
Feryok, A. (2013). Teaching for learner autonomy: The teacher's role and sociocultural theory. *Innovation in Language Learning and Teaching*, *7*(3), 213–225.
Godec, S., King, H., Archer, L., Dawson, E., & Seakins, A. (2018). Examining Student Engagement with Science Through a Bourdieusian Notion of Field. *Science and Education*, *27*(5–6), 501–521.
Hadibarata, T., & Rubiyatno, R. (2019). Active learning strategies in environmental engineering course: A case study in curtin university Malaysia. *Jurnal Pendidikan IPA Indonesia*, *8*(4), 456–463. https://doi.org/10.15294/jpii.v8i4.19169
Kamolpattana, S., Chen, G., Sonchaeng, P., Wilkinson, C., Willey, N., & Bultitude, K. (2015). Thai visitors' expectations and experiences of explainer interaction within a science museum context. *Public Understanding of Science*, *24*(1).
Kerby, H. W., Cantor, J., Weiland, M., Babiarz, C., & Kerby, A. W. (2010). Fusion science theater presents the amazing chemical circus: A new model of outreach that uses theater to engage children in learning. *Journal of Chemical Education*, *87*(10), 1024–1030.
Lamb, M., & Wedell, M. (2013). Inspiring English teachers: a comparative study of learner perceptions of inspirational teaching. *ELT Reserach Papers*, 7.
Lane, B. E. S., & Harris, S. E. (2015). A New Tool for Measuring Student BERI Protocol. *Journal of College Science Teaching*, *44*(6), 83–91.
Lawson, M. A., & Lawson, H. A. (2013). New conceptual frameworks for student engagement research, policy, and practice. *Review of Educational Research*, *83*(3), 432–479.
Lin, P. Y., & Schunn, C. D. (2016). The dimensions and impact of informal science learning experiences on middle schoolers' attitudes and abilities in science. *International Journal of Science Education*, *38*(17), 2551–2572.
Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. John Wiley & Sons.
Ngabekti, S., Prasetyo, A. P. B., Hardianti, R. D., & Teampanpong, J. (2019). The development of stem mobile learning package ecosystem. *Jurnal Pendidikan IPA Indonesia*, *8*(1), 81–88.
Pallant, J. (2013). *SPSS survival manual*. McGraw-Hill Education (UK).
Pianta, R. C., Hamre, B. K., & Allen, J. P. (2012). Teacher-student relationships and engagement: Conceptualizing, measuring, and improving the capacity of classroom interactions. In *Handbook of research on student engagement* (pp. 365–386). Springer.
Reiss, M., Billingsley, B., Evans, E. M., Kissel, R. A., Lawrence, M., Munro, M., & Veall, D. (2016). *The contribution of natural history museums to science education*. Phase.
Riedinger, K., Marbach-Ad, G., McGinnis, J. R., Hestness, E., & Pease, R. (2011). Transforming Elementary Science Teacher Education by Bridging Formal and Informal Science Education in an Innovative Science Methods Course. *Journal of Science Education and Technology*, *20*(1), 51–64. https://doi.org/10.1007/s10956-010-9233-8
Roche, J., Cullen, R., & Ball, S.-L. (2016). The Educational Opportunity of a Modern Science Show. *The International Journal of Science in Society*, *8*(3), 21–30.
Roorda, D. L., Koomen, H. M. Y., Spilt, J. L., & Oort, F. J. (2011). The influence of affective teacher-student relationships on students' school engagement and achievement: A meta-analytic approach. *Review of Educational Research*, *81*(4), 493–529.
Roslan, R. (2014). *Primary Teachers' Talk in the Bruneian Context: Representational Fluency and Consequences for Science Classrooms*. The University of Queensland.
Roslan, R., Panjang, S. M., Yusof, N., & Shahrill, M. (2018). Teacher's feedback in teaching science in a bilingual Bruneian primary classroom. *On the Horizon*, *26*(2), 122–136.
Russell, J. L., Knutson, K., & Crowley, K. (2013). Informal learning organizations as part of an educational ecology: Lessons from collaboration across the formal-informal divide. *Journal of Educational Change*, *14*(3), 259–281.
Sadler, W. (2017). Evaluating the long-term impact of live science demonstrations in an interactive science show. *New Perspectives in Science Education*: *6th Edition*, 129–132. http://orca.cf.ac.uk/102227/2/Evaluating the Long Term Impact of Live Science Demonstrations in an Interactive Science Show.pdf
Sinatra, G. M., Heddy, B. C., & Lombardi, D. (2015). The Challenges of Defining and Measuring Student Engagement in

Science. *Educational Psychologist*, *50*(1), 37–41.
Stocklmayer, S. M., Rennie, L. J., & Gilbert, J. K. (2010). The roles of the formal and informal sectors in the provision of effective science education. *Studies in Science Education*, *46*(1), 1–44.
Taylor, C. A. (1988). The art and science of lecture demonstration. *Bristol: A. Hilger, 1988*.
Tiyarat, W. (2017). *Factors affecting engagement with informal science learning in Thailand : A Regional Analysis*.
Vygotsky, L. S. (1978). *Mind in society (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.)*. Cambridge, MA: Harvard University Press.
Watermeyer, R. (2013). The presentation of science in everyday life: The science show. *Cultural Studies of Science Education*, *8*(3), 737–751.
Walker, G. J. (2012). *Motivational features of science shows*. Unpublished Ph.D. thesis. Canberra: The Australian National University.

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