Weaving Culture and Science: A reflection on teaching science through story-telling

Integrasi Budaya dan Sains: Satu refleksi Pengajaran Sains melalui Kaedah Bercerita

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ABSTRACT

Implementing culturally responsive education is possible by incorporating story-telling into science teaching and learning. It can be viewed as one way to present new scientific concepts or information that may be complex or difficult to comprehend. This study uses a local Malay folklore story, *'Hang Tuah dan Keris Tamingsari'*, alongside a hands-on activity during an after-school holiday program for primary students in a local library. A total of 25 participants were involved and their written reflection was collected. The collected data and images were coded and analysed along with the participatory observation. The results indicate that while participants expressed fascination with the story and the handicraft activity, they struggled to recall the science concept. Many mentioned learning about Hang Tuah and its noble values, emphasizing their engagement with the story and the craft rather than the intended science learning. This suggests the need to improve the alignment between the story, hands-on activity, and the science concept conveyed in the story. However, this is not a conclusive study as the findings may be influenced by factors such as the age group, duration of the program, and the reliability of participants' reflections. Several recommendations are provided to enhance the delivery of science content through story-telling in future research.

Keywords: story-telling, culturally responsive education, culture, Hang Tuah, science education

Abstrak

Pendidikan responsif budaya boleh dilaksanakan dengan mengintegasikan elemen cerita rakyat dalam pengajaran dan pembelajaran sains. Pendekatan sebegini berupaya menjadi salah satu cara untuk menyampaikan konsep atau maklumat saintifik baharu yang kompleks atau sukar difahami dengan mengambil kira konteks tempatan. Kajian ini bertujuan untuk meneroka pendekatan pendidikan responsif budaya melalui cerita rakyat Melayu, 'Hang Tuah dan Keris Tamingsari', melalui program cuti sekolah di perpustakaan. Program ini melibatkan seramai 25 orang pelajar sekolah rendah dan data diperoleh melalui data refleksi secara bertulis dan imej. Data-data tersebut dikodkan dan dianalisis seiring dengan pemerhatian penyertaan. Dapatan kajian menunjukkan bahawa, walaupun 1) peserta tertarik dengan cerita dan aktiviti, namun 2) peserta kurang mengingati konsep dan fakta saintifik dan 3) kebanyakan peserta mampu mengaitkan cerita dengan nilai-nilai murninya. Kajian ini mencadangkan keperluan untuk menambah baik penjajaran cerita dengan kandungan sains,

penyesuaian aktiviti, dan kedalaman konsep sains yang disampaikan dalam cerita. Walau bagaimanapun, kajian ini tidak bersifat konklusif kerana dapatan kajian ini dipengaruhi oleh factor-faktor seperti kumpulan umur, tempoh program, dan kebolehpercayaan refleksi peserta. Melalui kajian ini, cadangan penambahbaikan telah disarankan bagi menjalankan pendidikan responsif budaya berdasarkan cerita rakyat tempatan pada masa akan datang.

Kata Kunci: *Bercerita, pendidikan responsif budaya, bercerita, budaya, Hang Tuah, pendidikan sains*

INTRODUCTION

Recently many researchers have advocated for culturally responsive education, which is essential for effective classroom teaching and learning (Alejandro, 2021; Brown, Ring-Whalen, Roehrig, & Ellis, 2018; Garvin, 2016; Gay, 2000; Mensah, 2021; New York State Education Department, 2019; Smith, Avraamidou, & Adams, 2022). Culturally responsive education employs the unique cultural attributes, experiences, and perspectives of students from diverse ethnic backgrounds as teaching aids to enhance their academic outcomes (Gay, 2000). It is based on the belief that incorporating academic knowledge and skills within the context of students' personal experiences and reference frames makes learning more appealing, comprehensible, and personally relevant to them.

Culturally responsive education emphasises learning science corresponding to the students' real-world experiences, cultural practices, and identities. Wallace et al. (2022) proposed four fundamental principles in culturally responsive science teaching to increase students' interest in and comprehension of science and their perception of themselves as competent and confident learners: 1) value what students bring to the classroom as assets and resources for teaching and learning; 2) draws upon students' cultures to strengthen and sustain their cultural connections; 3) adopt a critical stance toward socio-political structures and processes and; 4) holds high expectations for all students' academic learning.

PROBLEM STATEMENT

Having that there are multiple points of entry in implementing culturally responsive education, this study focuses on incorporating story-telling into science teaching and learning (Gay, 2000; Georges Jr., 2020; Hunter-Doniger, Howard, Harris, & Hall, 2018; Wallace et al., 2022). In the teaching and learning science, students often struggle to understand certain concepts due to inherent complexity or difficulty and a lack of existing schemata for the accommodation and assimilation process (Dahlstrom, 2014) and, thus disconnected from the students' cultural context. This may lead to misunderstanding and compensate for the lack of understanding by rote memorisation (Csikar & Stefaniak, 2018). Therefore, it argues that teaching and learning science should support the learning environment where students feel valued and engage meaningfully with science concepts (Brown, Ring-Whalen, Roehrig, & Ellis, 2018; Garvin, 2016; Marosi, Avraamidou & Galani, 2021).

Story-telling serves as one of the representation strategies to explain scientific concepts or information that may be complex or difficult to comprehend (Csikar & Stefaniak, 2018; Wallace et al., 2022). Stories can illuminate teachers' pedagogical practices and thought processes, which reflect their learning and sensemaking of what culturally responsive education can look like in their particular science classrooms and contexts with their students (Hadzigeorgiou, 2016). This strategy uses students' cultural contexts and experiences to enhance their comprehension and interest in science, which can help students see the connections between science and their cultural identities and engage with science meaningfully and relevantly (Csikar & Stefaniak, 2018; Matamit, Roslan, Shahrill, & Said, 2020; Roslan, 2008). Several studies supported the practical use of story-telling techniques in the classroom. For instance, this technique engages students by improving their learning and retention (Krupa, 2014; Olson, 2015) and increases meaningful emotional involvement (i.e., evoking an emotional response) increases information retention (Lencioni, 2004; Steidl, Razik, & Anderson, 2011).

OBJECTIVE

This study reflects on using story-telling to deliver a simple science concept during an after-school holiday programme for primary students in a local library. A local Malay folklore story entitled *'Hang Tuah dan Keris Tamingsari*' was presented, and the concept of the alloy was highlighted upon describing the weapon. The session ended with a craft activity whereby the students were required to construct a paper dagger and decorate it creatively. The findings of this study will contribute valuable insights and enhance the existing body of knowledge in employing story-telling in the field of science education.

LITERATURE REVIEW

The art of story-telling is ingrained in the histories and cultures of people worldwide. It is a practice that can serve as both a window into another person's life experiences and a mirror through which one can examine one's ideas and beliefs (Hadzigeorgiou, 2016). Every story has protagonists, antagonists, and a setting and events unfolding across time. Telling a story requires two parties, the teller and the listener because the exchange of information between the two is essential to developing the narrative (Wallace et al., 2022). Educational story-telling can be divided into two broad purposes: assessing pupil knowledge or delivering content. (Csikar & Stefaniak, 2018). The advantage of using story-telling to assess knowledge is that the learner is required to put the provided information into their terms. This study focuses on the use of story-telling to deliver content in the teaching and learning of science.

Three important principles are essential in an instructional story that engages the audience: conflict, authenticity, and entertainment (McDonald, 2009). Conflict in a story refers to the tension that arises when one character's desires oppose those of another, with external forces or even those of the same character. All captivating stories revolve around a central conflict that may be instrumental in eliciting deep discussion on a topic. In the story of *Hang Tuah dan Keris Tamingsari*, a few opposing characters require dynamic poses, facial expressions, and challenging questions to convey a sense of conflict and tension. For example, the fight between *Hang Tuah* and *Tamingsari*, when *Hang Tuah* was wrongly accused by his opponent in front of the Sultan, and the highlight, when *Hang Tuah* was instructed to kill his best friend, *Hang Jebat*, represent some of the interesting conflicts in the story.

The authenticity of a story is reflected by having the characters show real feelings and react realistically. When a story feels genuine, it's easier for the audience to connect with the characters and see themselves (and their feelings and reactions) reflected in the story. The audience is more likely to project their own thoughts and feelings onto a character they can relate to. The authenticity of *Hang Tuah dan Keris Tamingsari* was represented by showcasing real-life elements such as wearing traditional costumes (refer to Appendix 1), replica of dagger, acting out specific parts of the story, and lastly, asking the audience about their feelings that resonate with the character. For example, questions about: *Hang Tuah*'s choice of loyalty to the Sultan vs. his friendship with *Hang Jebat* and *Hang Jebat*'s motive of rebellion against the King – did his end justify the means?

Lastly, a story has to be entertaining to hold its audience's interest and attention. There is no silver bullet for crafting a good story. The element of humour, suspense, and mystery can keep the audience engaged. Some may advocate leaving some of a story's aspects unsaid or unseen, urging the audience to think more deeply about the event and its consequences. The presentation of the story of *Hang Tuah dan keris Tamingsari* was intentionally weaved with elements of humour, especially during the short skit involving the helpers and the audience. The element of suspense and mystery were highlighted in the magical power of *keris Tamingsari* and related to the concept of alloy, which may contribute to the unique feature of the dagger.

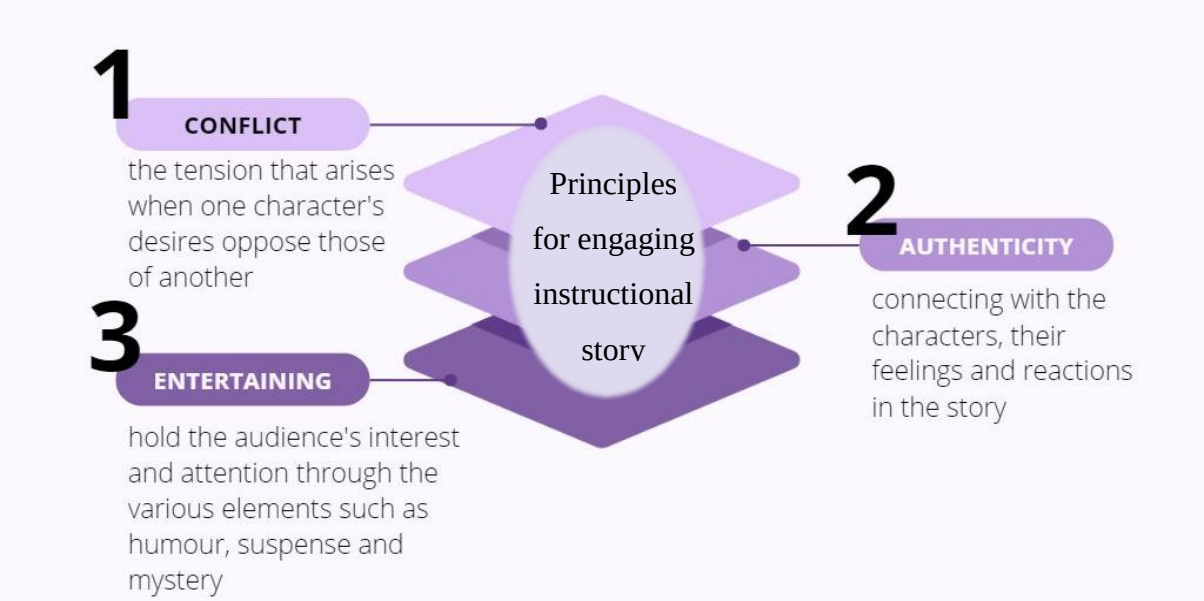

Figure 1. Principles for engaging instructional story

It is possible to tell, retell, relive, create, reconstruct, and dismantle stories. Studies have demonstrated that using stories is more persuasive than presenting statistical data, and stories may counteract statistical information (Betsch, Ulshöfer, Renkewitz, & Betsch, 2011). In other words, narrative evidence is more persuasive and credible than statistical proof. However, there are few studies and implementations of story-telling in science education. One possible explanation is that story-telling is not regarded as a subject or mode of information presentation requiring scientific rigour (Krupa, 2014). A narrative mode-generated story will not necessarily be converted into a scientific theory. The scientific maturity of a story involves a process of transformation into verifiability; it cannot rely on its dramatic origin. In other words, scientific maturity requires the paradigmatic (or logical-mathematical) method. Although the narrative mode of thought (and, by extension, a story or a myth) could be seen as the cause of the creation of artificial or even impossible worlds, this is not necessarily the case (Hadzigeorgiou, 2016).

Story-telling can play a more prominent role in school science education apart from many other strategies such as science fair (eg. Ong, Chou, & Yang, 2019), hands-on learning (eg. Azmah et al., 2016), cooperative learning (eg. Amedu, 2015; Yin, Tek, & Salleh, 2019). Hadzigeorgiou (2016) suggests that story-telling can help develop positive attitudes towards science, especially among female students with high verbal and mathematical abilities who do not select a career in a mathematics-based science field. He further highlights the importance of story-telling as an effective way to learn science in the early learning years. It is a more progressive approach to knowledge acquisition, and narrative and story-telling can enhance learning experiences and shape attitudes toward science. It is crucial to examine story-telling as an alternative method for teaching scientific information to students to enhance the contextual meaning behind the complex information and to aid in developing the schemata required to incorporate the information (Csikar & Stefaniak, 2018). The purpose of stories is to captivate the audience and elicit an emotional response. Students can benefit from the use of stories in courses not only to increase the previously mentioned contextual comprehension of the material but also to increase their engagement with the material and, consequently, their learning and retention of the information (Lencioni, 2004; Olson, 2015; Tan, Lee, & Hung, 2014). This engagement may inspire students to continue understanding a topic outside the classroom. Wallace's (2022) study also highlights the importance of story-telling as a tool for exploring and making sense of culturally responsive education in science classrooms. It also provides insights into the experiences and perspectives of teachers as they navigate systemic constraints and supports, connect through science, and develop strategies for culturally responsive science teaching.

METHODOLOGY

The participants in this study were students ranging 5 to 14 years old, who were registered in an after-school program. Purposive sampling was used to select participants based on their registration in the program. The study included a total of 25 participants. The data for this study was collected through participant journals, where they could reflect on their experiences and thoughts. The journals included written entries and images, allowing a more comprehensive understanding of the participant's experiences. The data collected from the participant journals were analyzed using a thematic analysis approach. The written and image data was coded to find emerging themes.

Participants were informed that their participation was voluntary and that they could withdraw from the study anytime. All participants were given pseudonyms to protect their anonymity in the study. One potential limitation of this study is the use of purposive sampling, which may limit the generalizability of the findings. Additionally, the use of participant journals may have resulted in a biased selection of data, as participants may have chosen to only write about specific experiences or topics. Finally, the thematic analysis approach used in this study is subjective and may be influenced by the researcher's own biases and perspectives.

Programme Details

A local Malay folklore story entitled '*Hang Tuah dan Keris Tamingsari'* was presented and the concept of the alloy was highlighted upon describing the weapon. The session ended with a craft activity whereby the students were required to construct an origami paper *keris*. This programme started with the planning of the programme with the librarians. Each child was provided a 8-page notebook made from coloured paper to write or draw their thoughts as guided by the speaker.

Table 1: Programme details

Phase	**Description**
Objectives	Children will be able to (a) Understand the story behind the *Keris Tamingsari* (b) relate some noble values in the story (c) Relate to the concept of alloy (d) Make and decorate a paper keris
Engage (15 minutes)	Notebook Name Age How are you feeling now?
Story time (30 – 40 minutes)	Background - Map of Melaka and Jawa – *kerajaan Majapahit* (Powerpoint) - Introduction of *Hang Tuah* and his friends (Skit) - The Visit to Majapahit - *Keris Tamingsari* - *Hang Tuah* was slandered (Skit) - *Hang Tuah* and *Hang Jebat* (Skit and video)
Noble values	Did *Hang Tuah* do the right thing? Do you think *Hang Jebat* action was totally wrong?
Facts about the keris	The concept of alloy - Definition - Advantages - Examples

	Facts about *keris* - Significance of *keris* today - Main features of *keris*
Activity (30 – 40 minutes)	DIY origami *keris*
Conclusion (15 -20 minutes)	Reflection time – notebook - If you have the magical *keris*, what superpower would you like to have? - Write down anything that you have learned today. - Which parts did you enjoy? Photo time

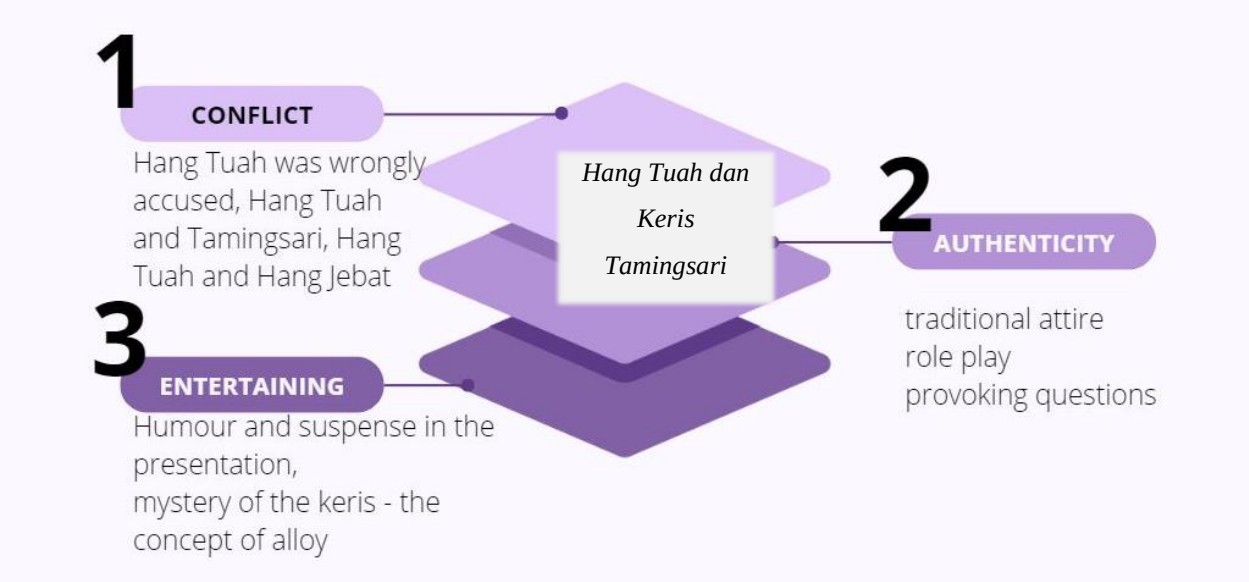

Figure: The story of *Hang Tuah dan Keris Tamingsar*i and the principles of engaging instructional story

The library made a promotional effort to reach out to local children in the area. 25 children signed up and participated in the activity. The session started with a 10-minute engagement time whereby the speaker got to know the children and explained briefly what they would do. The children were given a four -pages booklet to write or draw to express their thoughts during the session. They were asked to write their names, ages, and feelings before the session started. Then, the children were gathered to listen to the story; the speaker was in traditional attire. The story was presented in a combination of English and Malay. *Powerpoint* slides displayed the maps and some graphics related to the story. Besides, the speaker also engaged the audience by involving some of them to act in certain scenes of the story. Four youths were dressed in traditional Malay attire and assigned to demonstrate some scenes. A short video clip of the Hang Tuah film by Tan Sri *P. Ramlee* was also presented to highlight the fight between Hang Tuah and Hang Jebat. The alloy concept was introduced when the *keris Tamingsari* was highlighted in the story, and the significance of a *keris* is presented to relate to the current situation. The first and second page of Appendix 1 shows the photos taken during the programme, while the third page of Appendix 1 shows some samples of the thoughts and reflections written by the participants in the given notebook based on the given guiding questions.

FINDINGS AND DISCUSSION

This section describes some findings from the participants' notebooks and the researcher's reflection based on the participatory observation. There are four guiding questions for the participants to write down their thoughts. Before the programme started, they were asked to write or draw how they felt. Then at the end of the programme, they are asked to write or draw their thoughts based on these guiding questions:

If you have the magical keris, what superpower would you like?
Write down anything that you have learned today.
Which parts did you enjoy?
How are you feeling now?

The data is then extracted into a table as presented in Appendix 2. There were 25 children ranging from 5 years old to 14 years old. There was one respondent who did not write his age. This holiday programme was initially planned for children aged 7 – 12 years old. The diverse age group in this programme was probably due to some families registering their children with the elder or younger siblings, hoping they could learn together and help care for the younger ones. The highest number of children came from age eight, followed by age ten, as shown in Figure 3.

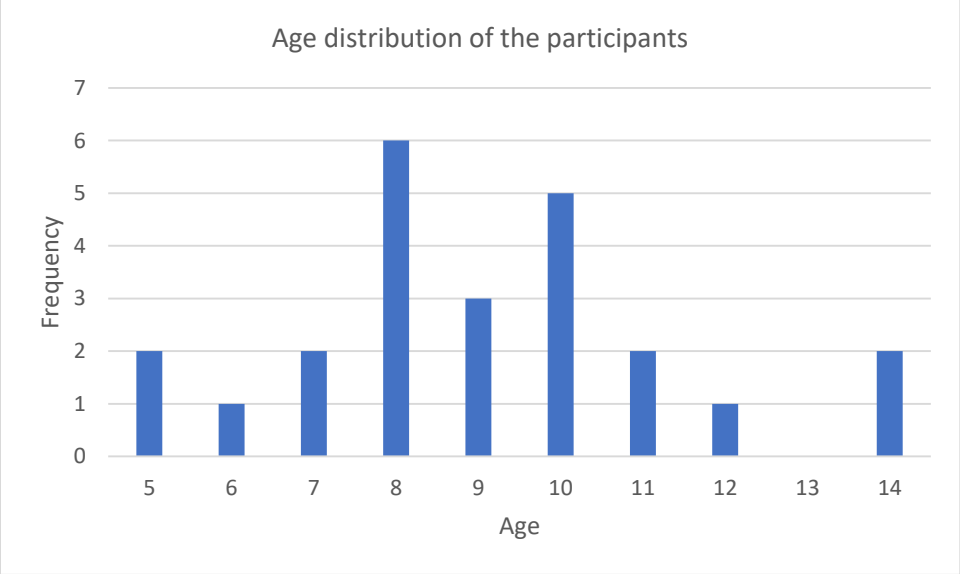

Figure 3: Age distribution of participants

The participants' responses was coded using open coding technique that involves initial exploration of data to identify and generate codes or categories. From the data, four codes were identified in what they learned during the programme: keris, noble values, *Hang Tuah* story and science/alloy (Figure 4). Some participants mentioned 2 or 3 aspects of what they have learned. The highest frequency code was noble values and *keris*. The code '*keris*' encompassed the making of origami keris and the facts about keris conveyed during the story-telling session. Only two responses acknowledged that they learned the scientific concept of alloy, which has the lowest frequency. Four main codes were identified on the aspect that participants enjoyed during the programme: presentation by the teacher, the skit, Hang Tuah story and handicraft. The highest frequency is the code handicraft, which indicates that most children enjoyed making origami keris. The second highest is the code story, whereby children mention they enjoyed the story of Hang Tuah and keris Tamingsari. The story, skit and presentation code can generally represent the story-telling session.

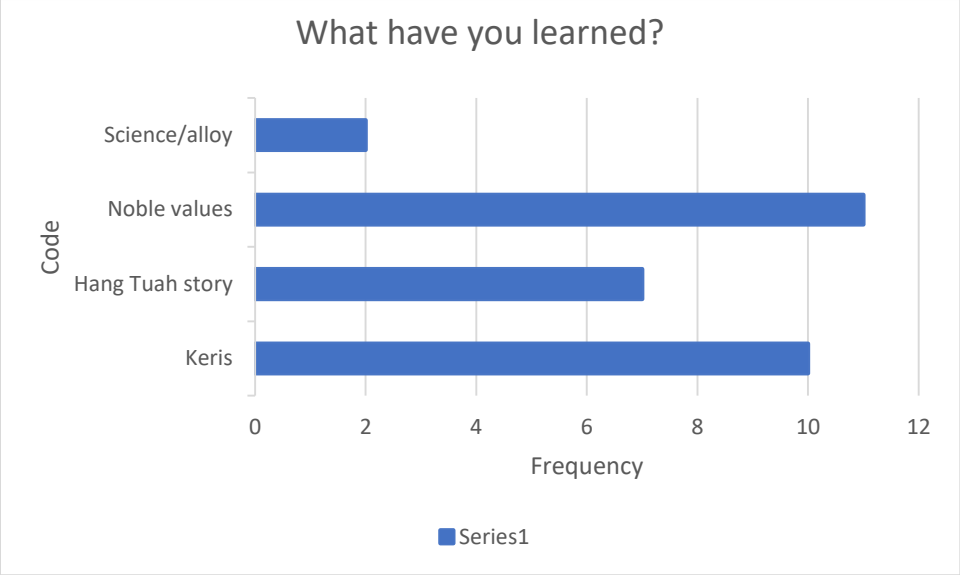

Figure 4: Code frequency for 'What have you learned?'

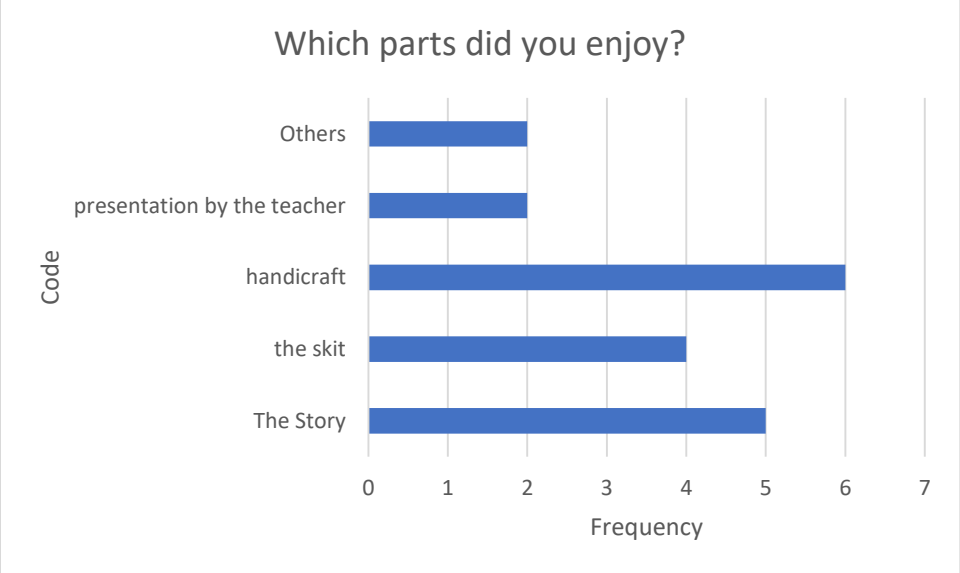

Figure 5: Code frequency for "Which parts did you enjoy?"

As for the reflection from the participatory observation, it was categorised as into two general themes namely, strength and weaknesses during the story-telling and the craft session as presented in Table 2.

Table 2: Summary of Strength and Weaknesses

	Strengths	**Weaknesses**
Story-telling	1. Traditional attire – Children were very excited to see a few facilitators and the speaker in traditional attire. It helped them to imagine the story more realistically. 2. The use of various ways to deliver the story kept the children engaged throughout the story-telling session. a) Graphic and description in Powerpoint Presentation b) Skit c) Audience participation in the skit d) Short video clip 3. The emotional expression of suspense, happiness, sadness and humour throughout the story led the children to appreciate the story and the noble values behind the story.	1. Too much emphasis on the story delivery overshadowed science content delivery. 2. Participants seemed to lose interest and motivation when the science content was related and explained at the end of the story. The connection and the transition from the story to the concept of the alloy can be further improved to cater to the needs of a diverse age group
Handicraft	1. Preparation of tools, materials and availability of a few youth helpers facilitated the handicraft session, especially with the younger children 2. Step by step explanation and folding of the origami keris was presented 3. Participants were allowed to decorate their keris according to their creativity and available resources.	1. The step-by-step folding was not visible for children who were seated far from the speaker. 2. The lack of time causes some of the younger ones cannot complete the craft and were helped by their elder siblings or the youth helpers

The main goal of this session is to relate a science concept through story-telling of traditional folklore. In this case, the concept and examples of alloy was highlighted in the story of *Hang Tuah dan Keris Tamingsari*. The role and essential characteristics of a *keris* were explained before relating it to a traditional belief that the blade of a *keris* must be forged with three different metals and that a part of the *Taming Sari*'s metal composition is made out of 21 types of different metal which made the *keris* so hard. From this point, the concept of alloy was incorporated with some real-life examples. However, based on the participants' reflection, only 2 seem to appreciate the science concept as a lesson they have learned. Most of them were fascinated by the story and the handicraft. Thus, instead of using story-telling as a means of emotional engagement, communication and motivation in learning, it seems that it was a distraction to the delivery of science content in this case. Although story-telling is believed to alleviate these communication problems, the findings suggest that there may be a ceiling effect on comprehension due to the complexity of the information (Csikar & Stefaniak, 2018). The information the participants retained was not shown to be specific detailed information and they may have remembered the overall story without recalling the science concept.

Using story-telling in science education can be more successful when teachers are devoted to providing quality teaching in terms of the time spent preparing the materials, teaching aids and activities

for their students. However, regardless of all the preparations, all teaching strategies would face challenges. The choice of the story and how it can support science teaching is crucial. The structure and content of the story need to explicitly relate to the science content intended to be taught (Walan, 2019). Apart from that, how the teacher presents the stories will determine if they will be interesting and meaningful to the students. Matamit, Roslan, Shahrill, & Said, (2020) identified some difficulties in using story-telling to deliver science content: it takes a long time to prepare a story and relate to specific science content, language barrier, learning environment, student's background knowledge, teaching aid and activities. Participants' background knowledge will affect their understanding of the science concept. For instance, in this case, most of them (76%) were aged 10 years and below. The diverse age group may be a barrier for many to relate and comprehend the science concept of alloy.

The handicraft session was one of the program's highlights, which many participants enjoyed. Participants followed a series of step-by-step instructions for paper folding to form the shape of a *keris*. This was followed by decorating the *keris* with materials such as washi tape, blink-blink stickers, glitter glue, and other types of stickers according to participants' creativity. Origami involves folding paper to create complex 3D shapes, which helps develop spatial reasoning skills. For instance, Boakes (2009) found that origami instruction can contribute to geometry understanding and spatial skills. Besides, origami requires fine motor skills and hand-eye coordination, which helps develop these skills, especially in young children (Anisa, Syafrudin, & Drupadi, 2021). Lastly, origami activity allows students to explore their creativity by experimenting with different folding techniques and designs, encouraging innovation (Supple, Neill, & Hao, 2021). However, in this case, the origami activity was a step-by-step instruction that required participants to follow instead of allowing them to explore different designs and innovations. This is because of time constraint and the diverse age group of the participants which may lead to frustrations especially for the younger children when they cannot complete the handicraft. On another note, hands-on activities do not guarantee meaningful learning in science if they are only focused on the activities (Crawford, 2014). Thus, hands-on activities must be carefully planned along with the combination of the story to teach and learn science effectively.

Implication

Considering these findings, we recommend that future research examine the potential benefits of having a more homogenous group of participants regarding their age group. This may facilitate the preparation of the story and relate it with the level-appropriate science concept and the hands-on activities. The delivery of the story can always consider various tools such as active role-play, video clips, actual artefacts, attire, or costume that relate to the story, which engages the participants in the story and the science concept. For example, in this case, the storyteller or teacher can bring replicas of *keris* made of different materials such as paper, plastic, wood, and metal before relating to the features of a *keris* and the concept of alloy. The teacher can improve the choice of the hands-on handicraft activity, and its implementation to connect to the science concept conveyed in the story. In this case, participants can explore and experiment with different ways to design and make strong *keris* using materials such as paper, plastic sheets, cardboard, aluminum foil, etc, instead of the teacher providing step-by-step instruction. Teachers may relate the combination of different materials to strengthen the paper *keris* with the alloy concept and its characteristics. Apart from that, making the *keris* can incorporate some basic electronics such as battery-operated LED on the dagger. This maker-centered activity will involve the application of the simple circuit, changing the session from a typical handicraft activity to a STEAM or STEM-based activity. This may serve as a simple project-based learning whereby young children can apply their knowledge and skills to the challenge of making a *keris* replica using the available material and relate to the concept of alloy.

CONCLUSION

Incorporating the story-telling of a local folklore story and a hands-on activity within a science lesson, it embraces the principles of culturally responsive teaching proposed by Wallace et al.(2022). Story-telling in science lessons acknowledges and appreciates the cultural background and experiences of the students. This story-telling approach recognises the knowledge and perspectives that students bring with them and validates their identities within the learning environment. It also allows students to connect their cultural heritage with the science concepts taught. It allows students to see the relevance of scientific ideas (the concept of alloy) in their cultural context, making the learning experience more meaningful and engaging. This approach strengthens their cultural connections and fosters a sense of belonging in the classroom. Exploring the local folklore story such as *Hang Tuah dan Keris Tamingsari*, encourages students to critically examine the socio-political structures and processes embedded within the narrative. This can include discussions on power dynamics, historical context, and the impact of societal beliefs on scientific knowledge. Students develop a deeper understanding of the relationship between science, culture, and society by analysing these elements. Integrating hands-on activities related to the folklore story and science concepts ensures that all students can actively engage in learning. Hands-on activities provide a multi-modal approach to learning, accommodating diverse learning styles and abilities. Setting high expectations for all students and providing inclusive learning experiences promotes equitable opportunities for academic success.

This study highlights the potential of incorporating story-telling into science teaching and learning to implement culturally responsive education. The use of a local Malay folklore story, *Hang Tuah dan Keris Tamingsari*, alongside a hands-on activity, aimed to deliver a simple science concept during an after-school holiday program for primary students in a local library. While participants expressed fascination with the story and the handicraft activity, their ability to recall the science concept was limited. The findings suggest that implementing hands-on activities can be improved to better relate to the science concept conveyed in the story. It is important to consider factors such as the age group, duration of the program, and the reliability of participants' reflections, which may have influenced the outcomes of this study. Therefore, caution should be exercised in drawing conclusive results from this study alone.

Several recommendations are proposed to enhance the delivery of science content through story-telling in future research. Additionally, further research can explore strategies to reinforce the integration of science concepts within the story-telling experience. This may involve incorporating additional discussions, demonstrations, or hands-on activities that directly address the scientific principles touched upon in the story. Such an approach would encourage deeper engagement and comprehension among students.

Overall, while this study highlights the potential of story-telling in science education, it also emphasizes the need for continuous improvement and exploration. By continuously refining the integration of culturally responsive education and story-telling, educators can create a more effective and impactful learning experience, ensuring that students appreciate the cultural elements and grasp the underlying science concepts.

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APPENDIX 1

Participants writing down their reflection before the session

Storytelling in traditional Malay attire

Skit casts

Group photo

Storytelling time

Skit during the story

facilitating in making origami keris

facilitating in making origami keris

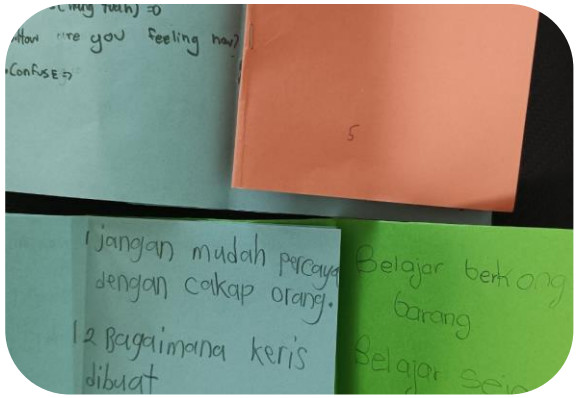
Making origami keris

facilitating in making origami keris

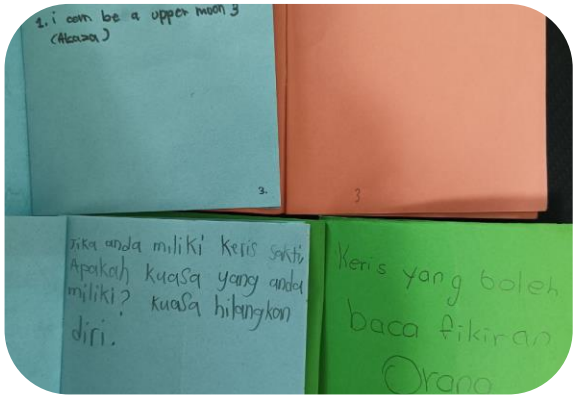
Decorated origami keris

Decorated origami keris

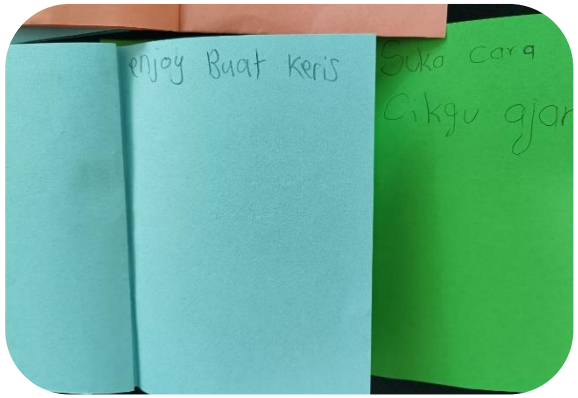
How are you feeling?



What did you learn today?



If you have the magical keris, what superpower would you like to have?



Which part did you enjoy?

APPENDIX 2

Feedback of participants extracted from the notebooks

Respondent	Age	How are you Feeling (start)	If you have the magical keris, what superpower would you like to have?	Write down anything that you have learned today	Which parts did you enjoy?	How are you feeling now? (end)
1	10	(Drawing)	telekinesis and telepathy	Story of Hang Tuah and making a keris	I did not enjoy sitting on the floor. I wanna sit on a chair	Stress
2	11	Sleepy	Teleportal	Respect the King and do whatever the king says	Stories of Hang Tuah	Confused
3	10	alitit	bantu orang	saya belajar buat keris	Saya enjoy lakonan	happy!
4	8	Happy	Kuasa hilangkan diri	Jangan mudah percaya dengan cakap orang; bagaimana keris dibuat	Enjoy buat keris	
5	14	(Drawing smiley)	boboiboy kuasa tiga	Jangan derhaka dengan sultan	Ketika Hang Tuah berlawan dengan Tamingsari	(Drawing of smiley face)
6	8	Happy	Saya hilangkan diri	Menolong kawan	Berlakon	Happy
7	10	(Drawing)	terbang petir	Jangan fitnah orang; Semangat berkawan		
8	12	(Drawing -of smiley face)	invisible	We should help our friend the correct way	I enjoyed doing the handycrafts	(Drawing of smiley face)
9		Sad				
10	10	(Drawing of smiley face)	I would like to pause time and rewind time	I learn about Hang Tuah's story	I enjoyed the story and the project	I feel happy
11	5	(Drawing of smiley face)	Api, Ais	Keris	.	.
12	5	(Drawing)	Drawing	.	.	.
13	8	(Drawing of emoji faces)	Invisible, telekinesis, teleport	Buat keris, story	I enjoy the story	

14	9	Im feeling happy	Keris yang boeh baca fikiran orang	Belajar Berkongsi Barang, Belajar Sejarah Hang Tuah	Suka cara cikgu ajar	I feeling happy
15	9	feeling happy	graviti	Jangan jadi dengki	all	happy
16	11	Sleepy	Water, never break (with 2 drawing of keris)	Origami keris, alloy, science, history of Hang Tuah		
17	14	Curious	The Power of Reading Minds	Saya belajar tentang cara membuat origami keris, sejarah hang tuah dan sains	I enjoy decorate the most. I want everything on my keris to be perfect	I feel hungy and happy
18	8	Happy	halimunan	belajar setia kawan	seronok buat keris	I feeling hungry
19	7	muka konfiden	jika saya ada kuasa keris saya mau kebalkan diri saya seperti keris taming sari	Saya belajar walaupun hang tuah difitnah tamingsari tetapi hang tuah tidak sesekali marah kepada taming sari	Saya suka dengan penyampaian cerita yang disampaikan	(drawing) muka konfiden
20	8	(drawing)	jika saya kuasa keris bantu orang	saya belajar buat keris	Saya enjoy lakonan	(drawing)
21	8	happy	Terbang, kebal, hilangkan diri	Belajar jangan fitnah orang		Happy
22	9	I'm felling happy	Keris yang boleh membuat orang cantik	Saya belajar membuat keris origami	suka gaya Hang Tuah	I'm feeling so Happy!
23	10	Happy	halimunan	membuat keris	berlakon	(Drawing of smiley face)
24	6	Happy	teleportation	what did I learn from the movie	today learn to do a kris	(drawing)
25	7	Happy	boleh terbang	Dia bunuh		