MODESTUM EURASIA Journal of Mathematics, Science and Technology Education, 2024, 20(11), em2531
ISSN:1305-8223 (online)
OPEN ACCESS Research Paper https://doi.org/10.29333/ejmste/15579

Empowering Malaysian early childhood practitioners' sustainable inclusive practices through the 'integrating and navigating Science, Technology, Engineering, Arts, and Mathematics' (inSTEAM) framework

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Received 20 June 2024 ▪ Accepted 04 October 2024

Abstract

This study investigate the Malaysian early childhood practitioners' science, technology, engineering, arts, and mathematics (STEAM) integrating understanding and practices. Several research studies continuously report that the learners' interest and motivation in STEAM are declining worldwide, and this reflects the current reality of the shortage of STEAM leaders and experts in the workforce. One of the primary purposes of STEAM learning in the classroom is to enhance the learning process and outcomes to prepare young children for a future STEAM-focused career. A qualitative approach of semi-structured interviews and classroom observations was employed to deeply understand the participants' practices on Malaysian early childhood STEAM integration. This study adopted the ground-up approach of the constructivist paradigm. This study interviewed 15 early childhood practitioners (including one center director) in several small groups from early childhood centers in the Metropolitan area of Kuala Lumpur, Malaysia. The findings showed how practitioners utilize their understanding and translate this into an integrated STEAM enactment. This study focused on practice-based inputs, where the practitioners also attempted to teach a makerspace lesson that focused on designing and constructing STEAM solutions. Using thematic analysis and coding of the practitioners' inputs and discussions, five themes arose from the analysis of the interviews. 'Character building STEAM educators', 'locus of control', 'risk-taking as part of STEAM learning', 'differentiating in STEAM lesson' and 'where interest-based learning fit in the local Malaysian curriculum' were factors that impacted the participants' drive and actions to integrate STEAM and makerspace. The findings informs other early childhood practitioners understanding and STEAM integration practices. Future study may include a continuous investigation to support early childhood practitioners to facilitate and deliver STEAM integration both inclusively and sustainably.

Keywords: STEAM, sustainable, inclusive, Malaysian, early childhood education

INTRODUCTION

In the past two decades, science, technology, engineering, arts, and mathematics (STEAM) education research at all year levels has gained broad international interest. The concern to continuously improve STEAM education and teaching practices globally continues to grow. The demand and expectation of future generations to utilize STEAM skills, such as creative and innovative approaches to problem-solving and effective communication, continually increases. Nurturing global citizenship is necessary to meet the rising international economic and STEAM workforce challenges (English, 2016; Marginson et al., 2013). STEAM education combines some or all STEAM disciplines into a lesson activity or curriculum with solid relevance to real-world problems (Moore et al., 2014). The international and national government and non-government associations have published multiple reports and policies to provide guidelines for countries to integrate STEAM into their existing curriculum (Academy of Sciences Malaysia, 2015, 2018; Kementerian Pendidikan Malaysia, 2011, 2016; Organization for Economic Co-operation and Development [OECD], 2019; United Nations, 2020).

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Contribution to the literature

- This is an empirical study to investigate Malaysian early childhood practitioners' understanding and first attempt to integrating STEAM based on the change of their perceptions through character building.
- This study presents a conceptual framework resulted from the findings to guide sustainable and inclusive practices when integrating STEAM in early childhood education that evolves around interest-based and differentiation.
- This study highlights how early childhood practitioners introduce risk taking and how the locus of control is managed when engaging with STEAM learning.

Most countries have introduced some form of STEAM education-related policies.

Several research studies continuously report that the learners' interest and motivation in STEAM are declining in countries like Australia, Malaysia and India (Kurniati et al., 2022; Thomas & Watters, 2015). The current reality of the shortage of STEAM leaders and experts in the workforce also shows a trajectory forecast of the ongoing insufficient younger generation choosing to pursue a STEAM career (Kelley & Knowles, 2016). Because of this need, many policymakers, world leaders and education systems are investing heavily in promoting STEAM competencies. This has led to an increased need for research focusing on integrating STEAM across disciplines into classrooms. Some of the earliest STEAM education research was conducted in the United States in the 1990s. However, the ongoing question of how to integrate effectively has been a long-term concern (English, 2016; Marginson et al., 2013). Thus, this study will focus on empowering Malaysian early childhood practitioners to integrate STEAM into their teaching and curriculum. The findings will provide an early insight into the needs and experiences of Malaysian practitioners in integrating STEAM. I know very limited evidence-based STEAM teaching practices are available for Malaysian teachers.

The Status of STEAM Teaching Practices in Early Childhood Education

One of the primary purposes of STEAM learning in the classroom is to enhance the learning process (Meyrick, 2011) and learning outcomes (Adam, 2004; CEDEFOP, 2017). This can lead to development in academic learning achievement, attitude, motivation, problem-solving skills, and higher-order thinking skills (Saraç, 2018; Yildirim, 2016). Interestingly, several studies highlighted the subject area, duration of learning, and learning conditions that impact the learning process and outcomes (Marton et al., 2014; OECD, 2019). Thus, as pointed out earlier, with STEAM education on the rise, it is beneficial to consider the steps taken by different countries to integrate STEAM based on the local contextualized settings. In this study, I focus on understanding and unpacking Malaysian early childhood practitioners as this is the earliest form of formal education children receive.

Despite the differences in teaching, learning and local culture that exist in both Eastern and Western countries, both regions may have shared some similarities regarding the problems and challenges, such as the existing educational issues that exist in the education curriculum (Di, 2017; Hassan & Jamaludin, 2010; Lee et al., 2019). Research from Western countries reported that the younger generation's low interest influenced the rising interest in promoting STEAM education in pursuing science, technology, engineering, and mathematics (STEM), and STEM-related careers (Chesky & Wolfmeyer, 2015). Indeed, this low STEM career interest is faced by most Asian countries. The problem of low interest in STEM disciplines, the shortage of young talent in pursuing a STEAM career and the issues affecting young people are all global (Jayarajah et al., 2014; Kim et al., 2015). Thus, as an initial attempt to understand this phenomenon, this study explores Malaysian early childhood STEAM education.

There is a need for research to address the existing gap by understanding the genuine need for STEAM teaching and learning that can address the challenges faced by Asian countries, particularly Malaysia. There have been several promising studies conducted by researchers and teachers in Asia, primarily related to STEAM education over the last decade (Lee et al., 2019; Lutfi et al., 2018; Yıldırım & Altun, 2015; Yildirim, 2016; Yildirim & Selvi, 2016). More than two-thirds of STEAM education-related research is conducted in Western countries (Lee et al., 2019). Based on the limited studies focusing on the Eastern context, the current trend of STEAM integration in Asia focuses on extending interest in STEAM-related subjects and developing 21st century skills. For example, real-world problem-solving capacity, academic learning achievement, and higher-order thinking skills are desired (Lee et al., 2019). This study intends to understand STEAM integration in Malaysia by developing a teaching and learning approach contextualized and responsive to the local culture, as recommended by the following studies (Lee et al., 2019; Wahono et al., 2020).

Integrating STEAM

However, STEAM education has been defined in multiple ways in the literature (Baran et al., 2016; Bybee, 2013; Hsu et al., 2017), resulting in a level of ambiguity

that surrounds STEAM education and effective methods for its integration (Breiner et al., 2012). In essence, STEAM education can link the five silo subjects while applying real-world and authentic learning experiences for children. A STEAM lesson can allow children to learn through hands-on experiences for future challenges they might face (Cameron & Craig, 2016; Yildirim & Turk, 2018). Ideally, this involves a combination of the scientific way of thinking, the technological way of doing, the process of problem-solving through design technology and engineering, artistic understandings and expressions and the process of applying scientific knowledge and mathematics (Kennedy & Odell, 2014; Ng et al., 2022; Vasquez et al., 2020). However, integrating STEAM in early childhood classrooms is challenging and complex for early childhood education teachers. It places high expectations on early childhood practitioners to teach STEAM-related content meaningfully to ensure children understand the connection between STEAM knowledge and real-world practices. However, the attempt to integrate STEAM subjects into the existing curriculum may not be achievable if there is no genuine understanding of the uniqueness of each country's classroom needs.

Early childhood practitioners must build capacity and understand the know-how of developing a well-integrated STEAM curriculum that provides ample opportunities for children to learn in rich, relevant, and stimulating environments. For example, Yang (2022) and Yang et al. (2023) found that adopting culturally responsive pedagogies anchored into children's interests promotes children's critical thinking skills, problem-solving skills, and increased confidence in real-world applications. Thus, a culturally sensitive and responsive teaching approach to integrate STEAM concepts is crucial to Malaysian early childhood STEAM education. Makerspaces for all ages have emerged to support STEAM learning through creativity, community building, and hands-on learning. Many of the technologies available today come from a combination of technologies developed by previous generations. However, a makerspace is a place that allows children to form their community and engage with the tools and skills that will become part of their generation through their inquiry and creation (Strawhacker & Bers, 2018). Makerspace uses a design technology approach that supports STEAM integration practices that promote children's problem-solving, critical thinking and creativity skills (Strawhacker & Bers, 2018).

Given this contextual research background, two research questions guided this research:

1. What is the nature of integration in selected Malaysian early childhood STEAM education contexts?
2. What does STEAM integration mean, and what is the related integration process in Malaysian early childhood education contexts?

METHODOLOGY AND RESEARCH CONTEXT

A qualitative approach was employed for this research. Semi-structured interviews and classroom observations were employed to deeply understand participants' practices on early childhood STEAM integration. This study adopted the ground-up approach of the constructivist paradigm (Bryman, 2016). A ground-up approach involves analyzing various forms of data to identify relationships and patterns to form understanding and knowledge. Participants were invited to semi-structured focus group interviews before and after teaching the STEM lessons. They consented to be observed when they attempted to integrate STEAM formally through a makerspace activity for the first time in their classroom. The STEAM-integrated makerspace lesson also included sustainability perspectives via an adaptation of the "puddle the platypus" story (Melbourne Water, 2020). The readapted version focuses on "coco the croc" as the protagonist as many locals had sighted crocodiles living in the local river. Practitioners read the picture storybook to present the STEAM problem to their students. A makerspace can be defined as a place where people use manipulative materials to work on creative projects with others, including solving STEAM problems (Johnston et al., 2022). After reading the storybook, the practitioners supported the children to solve the problems posed in the story. As part of the makerspace activity lesson, the practitioners provided physical materials such as cardboard boxes, pipe cleaners, plastic bottle caps, paper cups, etc., for children to design prototypes to solve the STEAM problem of designing a device to clean the polluted river water.

There are two mediums of primary school systems in Malaysia: the local Malay-focused primary school and the vernacular primary school, where the medium of education includes the local or native language, either Chinese or Tamil. The current study focuses on children who intend to attend local Chinese-focused vernacular primary school after completing their early childhood education. The early childhood center is in the metropolitan area of the Kuala Lumpur Region. This study interviewed 16 early childhood practitioners including one center principal. Interviews were conducted in small groups. **Table 1** summarizes participants' education, training level and years of experience. The majority of the participants hold a diploma. However, there is an emerging trend for diploma holders to retrain to hold a bachelor's degree. Most diploma holders are Teaching Assistants. However, participant is the exception as this worker is a lead teacher. A role normally held by bachelor's holders.

Table 1. A summary information of the early childhood practitioner

Participant (No)	Highest education/training obtained	Years of teaching experience	Current position
1	DipECE	3	Teaching assistant
2	DipECE	2	Teaching assistant
3	DipECE	7	Lead teacher
4	DipECE & BECE (current)	7	Teaching assistant
5	BECE	8	Lead teacher
6	BECE	10	Lead teacher
7	BECE	16	Teacher
8	DipECE	5	Teaching assistant
9	DipECE	4	Teaching assistant
10	DipECE	2	Teaching assistant
11	DipECE & BECE (current)	11	Lead teacher
12	DipECE & BECE (current)	15	Lead teacher
13	DipECE	6	Teaching assistant
14	BECE	14	Lead teacher
15	BECE	18	Teacher
16	BECE	25	Principal center director

Note. DipECE: Diploma in early childhood education & BECE: Bachelor's in early childhood education

Interview question prompts based on the work of Ng et al. (2022) explored integrating and navigating STEAM (inSTEAM) framework that identifies both the factors and challenges that early childhood practitioners experience when trying to teach STEAM:

1. How important do you consider teaching STEAM in the early years?
2. What does integration mean to you?
3. How do you integrate STEAM, and can you elaborate on how you have done it in the past?
4. How often do you integrate STEAM into your teaching?
5. What factors do you think promote STEAM teaching?
6. What challenges have you experienced or foreseen will arise when integrating STEAM?
7. How do you plan to navigate the challenges that may disrupt your attempt to integrate STEAM?
8. Are there any particular tools or strategies you might be interested in using to help you teach STEAM?

The STEAM lessons that the practitioners implemented were all observed. The practitioners read the story coco the croc which is an adaptations of puddle the platypus (Water Melbourne, 2020). The story focuses on exploring water pollution, discovered by the protagonist of the story, coco which is the crocodile caused by our everyday decisions and habits (littering, dumping oil into the river, sewage system leaks, etc.). The storybook focuses on presenting the STEAM problem through a storytelling approach and then encouraging the participants to solve the STEAM problem by designing a prototype solution in Makerspace. The participants were provided with cardboard boxes, crafts materials, scissors, sticky tapes, and other recyclable household materials to work collaboratively designing and building the prototypes.

Ethics, Participants, and Data Analysis Procedures

This project had university ethics approval, and I received written informed consent from all participants. The 16 early childhood practitioners were nominated to participate by the kindergarten center director and staff. All showed a strong interest in participating when invited. All the early childhood practitioners had industry qualifications from Malaysian tertiary education providers. All the participants were female, ranging between 23 to 61 years old. They came from diverse, multicultural backgrounds, had various levels of teaching experience, and had worked as educators, assistants, or center directors.

The data included semi-structured interviews and observation notes. The notes were shared with the participants to clarify and confirm the accuracy of the observation of early childhood practitioners' teaching practices. The early childhood practitioners' perceptions and practices in both the interview and makerspace enactment provided insight towards understanding how they understand and taught STEAM through a makerspace lesson focused on designing and constructing STEAM solutions. The data was analyzed following a two-staged sequential plan, including transcribing and organising before analysis. This study adapts Quintão et al.'s (2020) method to ensure the collected data meets the protocol for qualitative studies in validity and reliability. The data were first transcribed and recorded as codes. Then, a thematic analysis was adapted to synthesize and understand the collected qualitative data (Denzin & Lincoln, 2008). Critical friends cross-checked and triangulated the generated codes to increase the study rigor and to ensure the generated codes, categories and themes aligned with the

study research questions (Ary et al., 2010). These evolving analytical processes were also saved as an audit trail to maintain consistency.

FINDINGS AND DISCUSSION

Data analyses highlighted how practitioners utilize their understanding and translate that into integrating STEAM enactment. This study also focused on practice-based inputs, where the practitioners also attempted to teach a makerspace lesson that focuses on designing and constructing STEAM solutions. As part of the design process, the early childhood practitioner drew on the connections of the STEAM subjects by providing children with an outlet to practice their knowledge while utilizing different everyday materials to design and construct a STEAM solution as part of the developing a continuous approach of integrating STEAM enactment and possibly introducing makerspace formally into the existing curriculum.

Six themes arose through the analyses of the interviews using thematic analysis and of the practitioners' inputs and discussions:

1. perception of STEAM education,
2. character-building STEAM educators,
3. locus of control,
4. risk-taking as part of STEAM learning,
5. differentiating in STEAM lesson, and
6. where interest-based learning fits into our local curriculum.

Perception of STEAM Education

Most people believe STEAM learning happens when cool gadgets and robotic tools are involved. This perception is a misconception that has held back early childhood practitioners from exploring further relevant appropriate STEAM learning within their classroom context (Christian et al., 2021; Margot & Kettler, 2019). This study found that it is a common challenge that many practitioners share in creating an integrated curriculum and introducing STEAM into existing practices. However, despite the misconceptions, the participants remained highly ambitious and interested in introducing some form of STEAM learning in their classrooms. They also discussed the possible options of seeking educational funding to invest in the correct tools. Other studies have reported similar results, where practitioners call for exemplary STEAM lessons, accessibility to STEAM materials and support for classroom integration (Baker & Galanti, 2017; Estapa & Tank, 2017; Margot & Kettler, 2019). Early childhood practitioner 1 and early childhood practitioner 2 noted the following that shared an insight into how STEAM teaching and learning was perceived:

> Early childhood practitioner 1: We must buy STEAM tools such as robotics gadgets, but we do not know how to teach. We sought help from more experienced teachers and applied for funding. In the local primary school, parents must invest in the (robotic) tool for children to learn [STEAM]. You need to be able to afford the tool to engage in STEAM learning. When I first heard about STEAM, I thought about the cool robotic gadgets, and there is almost no way that we can think of getting around it besides investing them in our kindergarten. Now we realize it's about solving problems and scientific thinking in each lesson, the engineering way of doing, rather than the tool we use to teach. It's moving away from the superficial way of learning and telling students what is expected of them.

> Early childhood practitioner 2: Adding to what [early childhood practitioner 1] said, maybe after this (discussion), we can consider and utilize recyclable materials such as cardboard boxes as part of design technology to try to teach. If we would like to include ICT tools, it will be an investment that requires more discussion. However, at least we can use what we have and start teaching some STEAM sooner than expected.

Both participants highlighted the shift in their perceptions of teaching STEAM, which has now evolved from focusing on gadgets and the availability of tools to using available everyday materials and STEAM pedagogies. This notion was further explored through character building to understand how it contributed to integrating STEAM into early childhood practitioners' practices.

Character-Building STEAM Educators

Character-building was apparent among the STEAM educators. The early childhood practitioners reflected on their strengths and existing practices, which are crucial and influential in helping to improve their practices' impact on children's learning and development (Aldemir & Kermani, 2017; Ong et al., 2016; Park et al., 2017). Their first STEAM integration attempt has guided early childhood practitioners to explore and understand their practices better than before. This approach was adopted by Mesutoglu and Corlu (2023) in their study to understand practitioners' STEAM integration. In the following example, early childhood practitioner 3 noted that they may be doing STEAM teaching and learning without realizing. The current focus is on enhancing rather than introducing to teach right from the beginning.

> Early childhood practitioner 3: I had a newfound understanding of technology and engineering after today's task. We were not confident and

> often taken aback by the terms, and we never felt we understood and knew enough to teach them … So, I think we are doing some form of STEAM teaching, not realizing we might have integrated STEAM into the lessons that we taught in the past.

As the early childhood practitioners reflected further, they discussed how providing a learning environment nurtures curiosity and creativity, the purpose of learning, and whether it is to do well in exams. Early childhood practitioner 4 also reflected on some of their similar existing practices, including STEAM. This process was akin to other practitioners who had undergone similar experiences in the study by Macdonald et al. (2020), where the process was a mindset change. Practitioners either reviewed their current practices and felt empowered to continue what they may already be doing or accepted and viewed the experience or perceived challenges differently. This was further explained by early childhood practitioner 4 and early childhood practitioner 5 and in the following example quotes.

> Early childhood practitioner 4: We are still academically oriented to tertiary education. As educators to our future leaders, has anyone pondered what we need to teach to develop? What are we aiming to nurture? As teachers, we must consider our social responsibilities beyond ourselves to our society and future leaders. Are we confident that we have prepared our children to make responsible choices? How can we do that if we have never experienced that ourselves or received training to teach those skills?

> Early childhood practitioner 5: I believe it is essential to educate STEAM because we need to help the children develop problem-solving skills, independence, and critical thinking … Starting STEAM in the early years is reasonable. It is also essential, but we are more 'curriculum' (rote learning based). If only we had more time, we would attempt to do this in our weekly class every Friday, which is to link all the subjects together. I think they benefit from the class as it is more multidisciplinary based.

The practitioners' newfound insights into their strengths or plans to adopt new lenses to view their existing practices reflected those found in the studies by McDonald (2016) and Perry et al. (2016). These practices and activities can be completed through professional development to empower early childhood practitioners (Aldemir & Kermani, 2017; Ong et al., 2016). Through reflection, practitioners may undo their anxiety or negative perception and develop a new sense of development to integrate and teach STEAM (Brenneman et al., 2019). This sense of new realization is often powerful and can impact multiple areas, such as understanding the need to nurture curiosity and creativity in early childhood classrooms (Murphy et al., 2019). This finding was similar to what the participants shared and revealed.

Locus of Control

The subject and discussion on locus of control were exciting and thought-provoking. Some schools in Asian countries such as Malaysia are still somewhat 'teacher' or 'academic' driven (Wahono et al., 2020). This often impacts the overall expectations of young children. Participants shared that children as young as three must receive formal education to increase academic preparedness. Thus, there was little time for exploration and play, even for children at the appropriate age to play while learning. Early childhood practitioners in this study work closely with children as young as three years. They shared that the expectations of them as educators are often quite demanding. The primary learning mode is still rote learning, where most of the learning happens within a teacher-centered classroom determined by the curriculum standards (Di, 2017; Meng et al., 2022; Tytler et al., 2017). As early childhood practitioner 6 noted:

> Early childhood practitioner 6: This is our first attempt to think of STEAM and integrate them. The classrooms are usually teacher-centered, formal and well-structured. We had more children than usual, and several early childhood practitioners were placed in the class to assist in 'supervising and supporting' children's learning. Usually, we had only one teacher teaching the subject, but four staff worked closely during the lesson. What will this look like as part of our day-to-day practice?

Practitioners noted that it was the first time they had had to think, integrate, and allow play within a STEAM classroom in their post-class debrief discussion. They raised the concern that they were prompted to think about the distribution of responsibility and ownership of learning. This was new for them and never given much thought, as it was never seen as fitting for the local classroom context. Most of the learning is usually based on and guided by workbooks. These findings are echoed in the research of others as well (Hartini et al., 2020; Lestari et al., 2018). In the example following, early childhood practitioner 7 and the principal provided insights on their first attempt to allow children to take the lead in their learning through building STEAM problem prototypes:

> Early childhood practitioner 7: The early childhood practitioners developed a prototype and used it to help inspire children while attempting the task. However, most of the

> children end up doing the same. Only a handful of students constructed something different. We know the need to share responsibility but are also unsure how to do this. Where do we start, and where shall the starting point of sharing be? We encourage children to take ownership but still somewhat need to scaffold and support them heavily.

This concern was shared by the principal, who commented the following:

> Principal: It was inspiring and powerful to witness the early childhood practitioners' urge to adopt a shared responsibility in the class, where children take ownership and lead their learning while engaging with real-life solutions. The early childhood practitioners were well prepared and provided choices of materials and tools to encourage learning and creation in their first attempt. This is a good start!

Risk-Taking as Part of STEAM Learning Process

The primary pedagogy approach used is the teacher-centered mode of learning. Thus, the children become used to heavy scaffolding and well-instructed learning activities (Torres-Crespo et al., 2014). Most children were left unsure and uncertain when required to take the lead in their learning. The early childhood practitioners had to scaffold, guide, or prompt the children to attempt the STEAM task themselves. In the following, early childhood practitioner 8 provided a summary of the teaching enactment.

> Early childhood practitioner 8: It took children a while to warm up. Children are not comfortable building something different yet. The children were trying to digest that mistakes and errors are welcomed and accepted wholeheartedly in this STEAM learning. They started to think after several prompts. They are drawing different models but are unsure of how to construct them. They are still trying to develop the visual images and reason behind the doability of their design. This explained why extra early childhood practitioners were needed, so extra help was available to guide and lead children's learning in smaller groups. At the end of the task, all students are enthusiastic about drawing, contributing or creating a STEAM prototype.

The insights by early childhood practitioner 8 provided a brief insight that also explores part of their effort and attempt to integrate STEAM. Early childhood practitioners often go beyond their requirements to help link learning with everyday life and the real world (English & Mousoulides, 2015; Meng et al., 2022). Early childhood practitioners want to nurture a strong sense of connection and develop highly transferable and applicable skills beyond the classroom walls (Promkatkeaw et al., 2022). Early childhood practitioner 9 elaborated and shared the following insight.

> Early childhood practitioner 9: Children do not always understand the content we teach from the books. It pushes us to be creative and innovative. How can we teach and explain this better? We used art to help explain. I bring toys/everyday materials from home to capture students' attention, making them relevant to them. Practitioners realized the importance and benefit of critical thinking resilience. Now we realize we do some form of integration every day. It is not a lot, but we are starting somewhere, moving beyond just once a week on Friday.

Early childhood practitioner 9's ideas also showed part of their attempt to equip children to take ownership and lead their learning journey. Willingness and openness to risk-taking are essential parts of this process. Thus, early childhood practitioners share that they introduce such practices by trying to be creative and innovate new teaching methods. The teachers had an hour once a week to help link all the content knowledge from the language subjects, Mathematics and Science, with a real-life connection. The teachers unconsciously did some form of STEAM integration.

Differentiating in STEAM Lessons

In the early childhood practitioners' attempts to teach STEAM for the first time, they have provided an open-ended, play-based activity. Tytler et al. (2017) noted that tasks like these can be easily differentiated as children could decide and attempt the task based on their interests and strengths. In this study, the early childhood practitioners also provided a prototype to model and help children construct a mental image when developing their models. In the following, early childhood practitioner 10 provided a summary of how the children responded to this new learning approach.

> Early childhood practitioner 10: We can provide a prototype to guide children in this first attempt. We usually worked based on questions in the workbook and rarely worked on any open-ended talk that could be easily differentiated. The open-ended task meets diverse learning needs, is high quality and easily accessible for all the children. Interestingly, despite the tasks being open-ended and easily differentiated, most children still 'developed' the almost exact sample model.

After attempting the differentiated open-ended task, the early childhood practitioners noticed that children utilize their strengths and interests to help solve the STEAM problem, similar to the findings of Garner et al.

(2018). Early childhood practitioners reflected a need to use creative teaching approaches, such as integrating STEAM into their practices. Early childhood practitioner 11 reflected on the learning approach.

> Early childhood practitioner 11: The differentiated activity provided alternative and open-ended answers. The activities allowed children to solve the STEAM problem using strength and personal interest by combining existing knowledge and simultaneously constructing new knowledge. Thus, we reflected and realized integrating STEAM is a trial-and-error process. There is no right way to teach; we must find the balance. There is no one way to teach integration, especially with young children. We want to incorporate books, cards, songs, visuals, chanting, rhyming, toys and everyday materials in our future STEAM lesson activities.

The early childhood practitioners' first attempt to differentiate through open-ended tasks motivated their future teaching practices. Such practices encourage children to use their strengths to help solve problems (Garner et al., 2018), crucial in promoting 21st century skills.

Interest-Based Learning

Early childhood practitioners considered some possible challenges that hindered them from introducing interest-led learning, considering the expectations set on young children as an outcome of the existing curriculum. However, there is a genuine need to understand and implement interest-based learning to motivate and engage children in a highly relevant learning environment (Vasquez et al., 2020). Early childhood practitioner 12 and the principal elaborated on how they perceived and attempted to include children's interests in the Malaysian vernacular primary school system. vernacular schools are where the medium of education includes the local or native language, either Chinese or Tamil. The current study focuses on students who intend to attend local Chinese-focused vernacular primary schools.

> Early childhood practitioner 12: We firmly believe that Malaysian [Chinese focused] vernacular primary schools are more taxing than the local Malay focused primary schools. Thus, we never had extra time for 'hands-on', 'play-based', or 'interest-led' learning. We need to stay focused and continue to develop the content knowledge to meet [Chinese] primary school future learning needs starting from the early years. Thus, this is the main reason all the schools adopted the rode learning model from a young age.

> Principal: We know what we must do to prepare the children for school. I strongly critique the existing curriculum as it kills the children's curiosity and interest. I acknowledge that play, inquiry, and exploration are a core part of early learning, but I wonder if we will ever find the time to fit that.

Despite the challenges expressed by the early childhood practitioner and the principals, some of the practitioners in this study were still motivated to nurture children's interests and used arts or set challenges to engage children in learning (Dilek et al., 2020; Lin et al., 2021). Early childhood practitioners attempt to link the real world with classroom learning to boost engagement and spark genuine interest. In the following, early childhood practitioner 13 and early childhood practitioner 14 summarized their attempt to promote interest-based learning in their teaching.

> Early childhood practitioner 13: During craft, we put them into small groups and try not to scaffold or help them. I often encouraged the children to be more independent and explore freely. We also encouraged children to support each other (peer-to-peer learning) if they needed help. We think we are teaching them to self-help when needed.

> Early childhood practitioner 14: We hope our children will develop an interest in solving problems in mathematics as this is an important life skill. In our Mathematics class, we often try to be more spontaneous and go beyond the books by linking the connection between real-life mathematical problems and the subject learning content. We think the children will be interested in learning if it is highly relevant.

According to the provided summary, the early childhood practitioners' attempt to nurture interest-based learning is inspiring. Despite existing challenges, early childhood practitioners still attempt to establish the connection between learning within classroom walls and the world beyond the walls, as recommended by other STEAM scholars (Vasquez et al., 2020).

SUSTAINABLE AND INCLUSIVE PRACTICE

The findings above can be considered from a sustainable and inclusive practice (SIP) perspective, where teaching and learning are culturally sensitive and responsive in practice. Under SIP, three key themes are evident:

(1) early childhood practitioner's perceptions and character building,

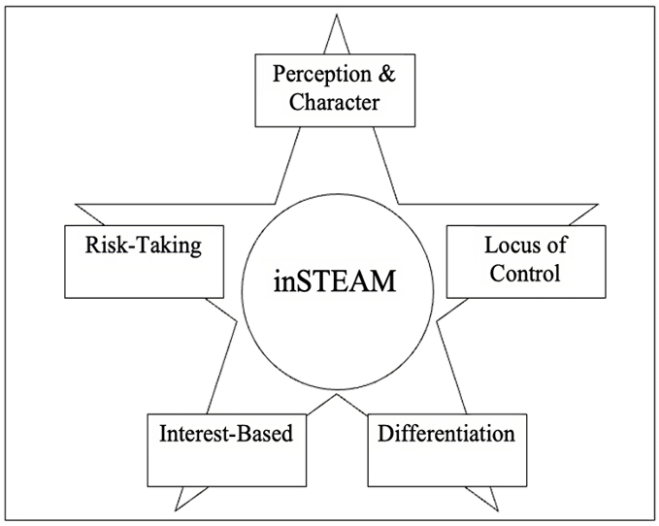

Figure 1. SIP of integrating and navigating STEAM (Source: Authors' own elaboration)

(2) the balance between encouraging risk-taking and early childhood practitioner's locus of control, and

(3) how can lessons be differentiated to meet the children's vast interest, strengths, and readiness.

SIP can empower and allow for ongoing continuity of integrating STEAM into the existing curriculum, moving beyond a one-off or infrequent approach. In essence, SIP is about understanding how to support and promote the early childhood practitioner in their practices of integrating and teaching STEAM in an ongoing way, thus normalizing it as part of the core disciplinary subjects in the existing curriculum. SIP can help promote a more profound interest in STEAM in early formal education, thus possibly encouraging later interest and success in STEM careers. This also works towards developing critical 21st century skills for unpredictable and unprecedented challenges that may arise in their later careers.

Figure 1 explains the critical relations of SIP and how it assists in integrating STEAM. Each point of the star is equal to show the importance of balance among the described phenomena. Integration and navigating STEAM are at the center of the framework, as reflected by the findings in this study, which have been used to understand the early practices of integrating STEAM effectively amongst Malaysian early childhood practitioners. The top point represents participants' perceptions and character building, which drove their desire to practice integrating and teaching STEAM. In the middle two points, 'risk taking' and 'locus of control' are placed opposite each other, reflecting the dynamic of both key practices. One does not over-or underpower the opposite. There needs to be a balance to maintain the shape of the star. Similar to the middle of the star, the bottom two points, 'interest-based' and 'differentiated' are placed opposite one another, so there needs to be balance between both corners to keep these two phenomena in balance. Interest-based and differentiated learning provides the foundations for STEAM education in the early years. Each of the star's corners reflects a unique and dynamic relationship with one another, where the main drive is to lead or to balance.

Teachers of very young children are developing an understanding that STEAM learning is crucial. It is the first step in developing SIP in STEAM integration. These understandings guide and develop practitioners' drive and desire to integrate and teach STEAM. However, despite some initial negative perceptions, these can be reversed or changed. Engaging in character-building tasks or learning aims to equip early childhood practitioners with the knowledge and confidence to encourage the willingness to attempt to integrate and teach STEAM (Kermani & Aldemir, 2015; Nesmith & Cooper, 2019). In this hands-on problem-solving lesson, practitioners utilized resources such as storybooks, soft toys and everyday recyclable materials to introduce and teach the lesson (Brenneman et al., 2019; Graves et al., 2016). Thus, practitioners experience a well-defined and accessible STEM integration experience that has empowered them and their practices (Counsell et al., 2015). Initially, some participants' perceptions were that STEAM learning only occurs when it involves utilizing and manipulating expensive gadgets and robotic tools. By providing early childhood practitioners an opportunity to learn, explore, and develop, different perceptions of the integration of STEAM are reported. Practitioners report feeling empowered and inspired to advance their teaching practices. Other researchers have also found this (Brenneman et al., 2019; Çiftçi & Topçu, 2022).

Through reflection, practitioners discover their strengths and adopt a new lens to view their existing practices (McDonald, 2016; Perry et al., 2015; Reimers et al., 2015). These practices and activities can be achieved through professional development to empower early childhood practitioners (Aldemir & Kermani, 2017; Ong et al., 2016). Through reflection, practitioners may undo their anxiety or negative perception and start developing a new attitude towards integrating and teaching STEAM. These senses of new realization are often powerful and can impact multiple areas, such as understanding the need to nurture curiosity and creativity in early childhood classrooms (Murphy et al., 2019).

As stated earlier, Malaysia's predominant learning mode is still rote learning, and teacher-centered classrooms focus on teachers' scaffolding and guidance. Rote learning has yielded high-performance results in international exams (OECD, 2019). However, the need for STEAM integration is still prevalent in Asian countries to promote 21st century problem-solving and critical thinking skills to prepare for the next generation and the challenges that are ahead (Hsu & Fang, 2019; Tytler et al., 2017; Wahono et al., 2020). The participants

in this study began to adopt a different approach to learning to encourage children to take risks and simultaneously consider the level of scaffolding to be provided. Early childhood practitioners work towards a safe environment to encourage children to explore without fearing making mistakes and taking the lead in their learning (Chu et al., 2022). The early childhood practitioners in this study were still somewhat exploring the balance between the locus of control in the classroom lesson and developing a safe learning environment to encourage risk-taking as part of the learning experience.

CONCLUSION

This paper has explored how Malaysian early childhood practitioners enacted an integrated STEAM lesson for the first time. The lesson related to water chemistry challenged the teaching and learning of teachers and children alike. Due to the nature of rote learning, interest-based hands-on learning was rarely a focus in the past. However, through STEAM integration, early childhood practitioners can consider capitalizing on students' interests as part of their learning in solving STEAM problems (Chiu & Krajcik, 2020). This also opens the possibility of meeting different learning needs and nurturing different interests through having ongoing, open-ended discussions with students. When tasks are interest-based and open-ended, it can be easy to modify and accommodate different learning needs (Cheng & Yeh, 2022; Tytler et al., 2017). As part of the impact of nurturing learning based on interest in a differentiated classroom, children were found to be more independent and work collaboratively with their peers, a goal promoted by Kementerian Pendidikan Malaysia (2016). The goal of nurturing learning through interest is ultimately trying to move away from the teacher-centered spoon-feeding approach and to encourage a sense of high relevance to each learner to boost a genuine interest in STEAM from a young age (Tytler et al., 2017; Wahono et al., 2020).

Extending beyond the implications for Malaysian early childhood education, the findings can be applied to other countries that have similar educational structures to Malaysia to support further the more significant implications for early childhood education and STEM (Tuyet et al., 2024; Husamah, 2022; Wahono et al., 2020). This is especially important in the Southeast Asian region that still focuses on using the Eastern approach to learning with a strong focus on rote learning and an exam performance mindset. The study findings highlight the nature of STEAM integration in Malaysian early childhood education contexts and provide insights into how STEAM integration was interpreted, understood and implemented into practice. The integration process in the context of Malaysian early childhood classrooms was discussed, hopefully inspiring more regional practitioners to start thinking about integrating STEAM into their teaching practices.

This research does have its limitations. The participants in this study were female only. The lack of male practitioners' perspectives may be crucial to understanding different perceptions and challenges in integrating STEAM. Historically, STEAM careers tend to be pursued by men. Thus, it would be essential to understand if male practitioners' attitudes differ from their female colleagues. This study was impacted by COVID-19 travel and lockdown restrictions, limiting the time in classroom settings. Thus, only the teachers' initial attempts at STEAM integration could be explored. However, as this paper indicates, a single lesson that challenges and empowers can reveal a wealth of new learnings. For the same reason, I could not include early childhood centers and practitioners outside of metropolitan Malaysia. It will be beneficial to study and understand additional practitioners' experience and possible growth development that they experience while integrating STEAM (Siew, 2022). During the STEAM lesson at the heart of the study, integrating assessment elements was not discussed as this was a first attempt. It is essential to understand how, when, and what to assess to introduce and strengthen the position of STEAM education into formal education. STEAM learning offers opportunities for meaningful learning, and the current study does not explore whether this also might translate into practical and meaningful assessment (Cheng & Yeh, 2022). Perhaps future studies also consider the position of purposeful assessment in STEAM classrooms and learning.

Funding: No funding source is reported for this study.

Ethical statement: The author stated that the study was approved by the Monash University Human Research Ethics Committee on 30 June 2022 with approval number 2022-32312-80491. Written informed consents were obtained from the participants.

Declaration of interest: No conflict of interest is declared by the author.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the author.

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