THE USE OF STEAM APPROACH IN PRESCHOOL FOR CHILDREN'S HOLISTIC DEVELOPMENT

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Abstract: This article discusses a research based on young children in the preschool setting. With the substantial evolution of technology, the 21st century young children are growing way more advance compared to the previous generations. To enhance the cognitive, language and socioemotional development of young children, it is vital to examine the teaching and learning approach in early childhood discipline. On that account, the study attempted to investigate the needs analysis for the STEAM approach in science and mathematics teaching in preschool classroom setting. Five in-service preschool teachers were selected through purposive sampling to participate in the semi-structured interview to collect comprehensive descriptive data on how the preschool teachers conduct their science and mathematics lessons in actual practice. Thematic analysis of the findings revealed four main themes with sub-themes for each construct. The findings indicated that the science and mathematics lessons were conducted rigidly according to the syllabus stated in the National Preschool Standard-Based Curriculum (NPSC). Consequently, the preschool teachers supported the implementation of Science, Technology, Engineering, Arts and Mathematics (STEAM) approach in order to cultivate enthusiasm and stimulate thinking skills among the young children towards a holistic development. This current research will raise the understanding of STEAM and its importance to all the early childhood practitioners and relevant authorities. Though the article only discusses the needs of the STEAM approach employed, the importance of this research in the Industrial Revolution (IR) 4.0 era indicates the significance of science and mathematics teaching of young children via STEAM to enhance all aspects of growth. It is hoped that constructive feedback will makeup to the reality of this magical power of the STEAM approach.

Keywords: *Science, Technology, Engineering, Arts and Mathematics (STEAM) Approach, Preschoolers, and Holistic Development*

INTRODUCTION

As years go by, the expansion of early childhood education discipline increases concern among the communities. The government has put concerted efforts to develop the preschool education system, either national preschool or private preschool, to fulfil the needs of the current market. Malaysian Ministry of Education (MOE) acknowledged that the significances of nurturing young children about the early years are vital to form the basis of personality, behaviour and intelligence (UNICEF, 2013). Seeing that early childhood education has prioritized, innovative approach must be exploited to increase the quality of the teaching and learning process in the Fourth Industrial Revolution (IR 4.0). Goliong and Talin (2018) revealed that young children have to be exposed to a dynamic, creative and productive approach to obtain knowledge and skills for higher academic achievement.

The comprehension and engagement in science and mathematics among students are relatively low, as shown in the ranking of Programme of International Students Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) internationally (Osman, 2017; MOE, 2017). Since this issue has become the primary concern for MOE, one of the actions taken is by introducing several pedagogies in the National Preschool Standard-Based Curriculum (NPSC) to provide a firm learning foundation from young age. However, several research indicated that the teachers are still insufficient of related skills to convey the concepts of science and mathematics (Ibrahim, 2019; Ismail, Salleh & Md, 2019). Consequently, the students encountered challenging experiences in learning both subjects while considered the teaching approach delivered to be theoretical which leading to poor comprehension among them (Hasbullah, Bakar & Othman, 2020; Nurkholisoh, 2020).

With the establishment of Science, Technology, Engineering and Mathematics (STEM) in national education system, the results of science and mathematics subjects among students are still low (MOE, 2017). This could be attributed to insufficient of trust among STEM teachers and students, a poor coordination between school management and teachers who anticipated to be more innovative and creative in instructing Science and Mathematics, as well as the school administrators' and management's professional experience in other subject areas or expertise (Ismail, Salleh, Md, 2019; Ibrahim, 2019).

STEAM is an innovative approach that comprised a more comprehensive coverage where it integrates the five key disciplines of Science, Technology, Engineering, Arts and Mathematics. It aids the young children with the natural curiosity and excitement, which as the foundation for critical thinking, creativity, and decision-making, which equips them for better academic performance (Barrett, 2017). The STEAM approach involves critical and creative thinking, decision-making, problem-solving and reasoning skills, and more of the implicit values (Shahali, Halim, Rasul, Osman & Zulkifeli, 2017). These skills are instilled through the STEAM approach in the play-based teaching and learning process to suffice the demands of Industrial Revolution 4.0 (IR4.0). Young children should be exposed to the scientific skills since early age as they learn rapidly throughout their childhood period. According to Hadani et al. (2018), the early learning experiences of children is the groundwork of their long-term thinking ability as well as shaping their attitudes toward learning.

Ministry of Education Malaysia (2013) has proposed strengthening the quality of Science, Technology, Engineering and Mathematics (STEM) in Malaysia Education Blueprint 2013-2025 to instil students with 21st-century skills. However, it is essential to incorporate ‘arts’ into STEM to enhance children’s cognitive level, motivation, engagement, and positive effects throughout their learning process (Henriksen, 2014). Several studies revealed that children who are given opportunities to engage in hands-on activities at the early childhood level are more likely to have a positive inclination towards subject areas of STEAM (DeJarnette, 2012; Sage & Faye, 2017). Meanwhile, play is the platform to expose children to a supportive environment and various practical activities to support their critical, imagination and cheerful disposition towards learning (Department of Education Employment and Workplace Relations of Australia, 2010). Hence, the current study that integrates play-based activities with STEAM approach may provide a platform for children to develop holistically.

LITERATURE REVIEW

With the advent of IR4.0, the skilled and high competencies workforces are required to meet the demands of 21st century. Yet, the current trend shows that the Malaysian students displayed low enthusiasm in STEM-related subjects in the schools (Mustafa, 2019; Ramli & Talib, 2017). The 2017 Annual Report by the Education Performance and Delivery Unit (MOE, 2018) has shown the data of 11 percent out of 89 percent Form Six students’ enrolment in science stream is relatively lower than the students in Social Science stream. This phenomenon has indicated that the academic performance of Science and Mathematics among the Malaysian students in Programme of International Students Assessment has been declining since 2015 (MOE, 2017). Despite the fact that the students were between the ages of 15 and 17, the results reveal that poor performance is attributable to a lack of grasp of mathematics and the notion of science (Martin et al., 2012). This has become a real cause for concern for the Ministry of Education, with students needing to comprehend this notion as early as possible since it may damage the future workforce necessary in Malaysia to prepare for IR 4.0. As a result, students must lay all the groundwork in early childhood education which shapes brain architecture and for a person's lifetime thinking abilities and attitude toward learning in order to make long-term preparations, as proposed by Herreras (2017). Therefore, the study will look more into what could be done to the former approach of STEM to become STEAM approach by integrating ‘arts’ in any subject matter of learning process, at the preschool level to cultivate the enthusiasm in learning science and mathematics.

In order to promote comprehensive human capital with creative, critical, and inventive thinking (Cyril, 2018) from young age, the National Preschool Standard-based Curriculum (NPSC) as the basic guideline for preschools in Malaysia, has identified six main strands that characterize different areas of child development in the teaching and learning process: Communication; Science and Technology; Physical Development and Aesthetics; Personal Competence; Humanities and Spirituality; Attitudes and Values. To maximize the efficacy of the teaching and learning process, the NPSC lists a number of teaching and learning techniques (MOE, 2017) that pre-school educators can use to achieve the six strands' goals: child-centered learning, learning through play, inquiry-based

learning, integrated approach, thematic approach, project-based learning, mastery learning, and contextual learning (MOE, 2018).

According to Ong et al. (2016), STEM is feasible to be integrated into the Early Childhood Curriculum. When the STEM approach has been updated to STEAM with the addition of "Arts" element, it is even more appropriate and usable in the preschool curriculum to provide children with more meaningful and enjoyable learning. As STEAM integration allows for the junction of the arts and STEM domains, which can assist unlock creative thinking and innovation while also increasing student engagement and learning (Robelen, 2011). According to Lindemean et al. (2014) and Quigley and Herro (2016), incorporating a STEAM approach into the educational system allows young children to develop their innovative, creative, and critical thinking skills, as well as learn to collaborate and interact with their peers. While Brouillette and Graham (2016) and Ghanbari (2015) stated that students who actively participate in STEAM learning encountered a higher achievement than their peers, possessed a higher level of learning retention and experienced more enjoyment in the learning process.

As part of the STEAM approach, the 'Arts' element included not only drawing, colouring, and painting, but also activities that required the children's imagination and ingenuity, such as music, pretend play, and other play activities that allowed them to see the communication between the idea and creativity in the design and development of the lessons. As Smelová and Stolinská (2021) pointed out, play is a vital activity for preschool children because it allows them to be spontaneous, apply their knowledge, abilities, and emotions, and provides infinite chances as well as new stimuli, interactions, and social contacts. They (2018) discovered that play is far more appropriate and abundant for young children than formal learning since it allows for integrated learning.

In the context of STEAM approach, play as a kind of arts is the nature of young children, acts as a crucial element which enhances children's cognitive level, allows more motivation, engagement and provides positive effects in teaching and learning process of STEM (Henriksen, 2014; McGrath & Brown, 2005). Subsequently, the characteristics of play give young children greater opportunities to learn and explore through play as the nature of learning in their growth. Children who played for longer periods of time saw quick cognitive improvement, developed better communication skills, refine children's locomotive abilities such as muscle development, strength, coordination and aerobic stamina, improve emotional flexibility and developed more positive emotion as in improving their self-awareness and self-esteem (Ahmad, Hussain, Batool, Sittar, and Malik, 2016; Wathu, 2016; Goldstein, 2012; White, 2012; Aliza and Zamri, 2011; Little & Wyne, 2008). Thus, integration of play-based activities with STEAM approach will be one of the innovative strategies for pre-school teachers as their guides in the teaching and learning process. As play not only aids in their growth but also serves as a source of information for the teachers (Smelová & Stolinská, 2021).

According to Pyle and DeLuca (2017), play-based learning is child-centered and focuses on young children's development, interests, and talents by allowing them to participate in and establish appropriate academic learning contexts. While Thompson (2001) mentioned that the degree of passion among young children will be raised at their most rapid growing period of human life development if the STEAM approach is implemented with the integration of play in preschool education. By combining play-based activities with a STEAM approach, young children can be exposed to problem-solving activities in a fun and structured way. STEAM was established to help kids develop their whole selves, not just their knowledge and abilities, but also their values (Bahrum, Wahid & Ibrahim, 2017). While Young (2017) found that teachers perceived STEAM as an effective strategy to stimulate interests in learning science and mathematics among the students. Therefore, the integration of the NPSC and pedagogical teaching and learning strategies with STEM approach at the beginning to STEAM approach recently in the preschool level has enriched the young children's interesting learning process and helped to promote critical and creative thinking skills among the young children.

STEAM activities provide a natural platform for children to collaborate and communicate. Children are naturally drawn to STEAM topics because they like exploring and experimenting in their natural surroundings (DeJarnette, 2018). More critical thinking, enquiry, and problem-solving exercises that foster process skills rather than content knowledge are needed in science education (DeJarnette, 2012). They want to learn fundamental concepts and develop a better understanding of how the world functions (Koester, 2013). With their sense of inventiveness, curiosity, and perseverance, preschoolers have a natural affinity for science (Banko et al., 2013). Planning a lesson integrating different STEM subjects is time consuming, and teachers not always find the necessary time for it (Park, Byun, Sim, Han & Baek, 2016). Also, before learning teaching methodology of STEM subjects, they need to have content knowledge in one or more disciplines in STEM and they have to understand the integrated approach to STEM (Pimthong & Williams, 2018). The results highlight the importance of integrating STEM Education in the

training of future preschool and organizing teacher training courses on STEM Education for in-service teachers and offering them continuous specialized support. Collaborative or grouping activities in the STEAM approach also gives rise to a sense of personal and interpersonal responsibility in the learning process, thereby building children's understanding of the material being studied (Ellizah, 2020).

METHODOLOGY

The present study was conducted by employing qualitative method which is commonly used in education disciplines (Merriam, 2009, p. 22). It entails an interpretative, naturalistic approach to investigating the subject matter (Flick, 2018; Punch, 1998; Denzin & Lincoln, 1994). With this implementation, it is sought to analyze the needs for STEAM approach in teaching early science and early mathematics. To obtain the in-depth and rich descriptive data, the data has been collected through semi-structured interviews with the preschool teachers. The five preschool teachers from national and private preschools with qualifications in early childhood education and at least five years of working experience were selected to participate in an interview session to acquire the needs of STEAM approach in the preschool setting. They have been identified through purposive sampling based on their experience and common engagement in preschools, especially in the early science and early mathematics, and their openness to contribute to the research study. The data collected from the interview has illustrated how the preschool teachers typically carry out their science and mathematics lessons.

Prior to conducting the interview, the interview protocol was developed based on literature review and adapted from research conducted by Qin (2018) and Suraya Bahrum (2018). It was validated by subject matter expert in the field of early childhood education to assure its validity and reliability. The interview protocol involved asking preschool teachers to provide details such as effectiveness of implementation of science and mathematics learning for preschool children as well as difficulties encountered throughout the process. With these information, it allows the researcher to better capture the perspectives of participants in a broader view and richness pertaining to their engagement in teaching early science and mathematics in preschool classroom setting.

The researcher clearly explained the purpose of the current research study and other related details to the participants before conducting the interview session. The participants were required to sign a consent form beforehand to get their approval on using the information given for research purposes. With the guide of the interview protocol, the interview had been audio-recorded and transcribed. Subsequently, the interview transcripts were checked by the interview participants to confirm their accuracy. This is 'member checking' as suggested by Merriam (2008) to enhance qualitative data reliability and validity.

After data collection, the data was then transcribed based on the commonly employed method of thematic analysis for qualitative data. The researcher initiated the data analysis process with open coding followed by axial coding and selective coding (Merriam, 2009; Strauss & Corbin, 1998). The codes were then formed into the potential themes or subthemes to emerge (Vaismoradi, Jones, Turunen & Snelgrove, 2016). Lastly, the assembled details were reviewed critically and then examined before formulating the initial codes. It was followed by identifying and formulating the data in analysis matrices using the patterns and themes. Then, the researcher compared and combined the similar codes from the interview data as appropriate to the categorization of the codes, which led to the emergence of themes regarding the needs of STEAM approach in the teaching and learning process of early science and early mathematics.

RESULTS

The needs analysis for integrating play-based activities with STEAM approach in preschool's teaching and learning of science and mathematics of the study was investigated and the findings were categorised into four primary themes: 1**)** approach used in typical lessons**;** 2) science and mathematics learning for pre-schoolers; 3) awareness and understanding on STEAM approach; 4) pedagogical content knowledge in teaching. Each of the theme consists respective subthemes which reveal the data in detail regarding the need analysis in integrating the play-based activities with STEAM approach.

The approach used in typical lessons refers to the methods or strategies that the pre-school teachers commonly apply in the mathematics and science teaching and learning process. The subthemes which were explored under the approach used in typical lessons are: 1) allocation time; 2) setting of lessons; 3) approach used in teaching; 4) role of teacher; 5) teaching and learning materials used; and 6) topics and contents of the lessons.

Based on the findings, most of the preschool teachers usually allocate 40 minutes per week for early science and early mathematics lessons, which is similar to the time allocation stipulated in the National Preschool Standard-Based Curriculum (NPSC). One of the preschool teachers scheduled science and mathematics classes three times a week for 40 minutes each as below.

> *"Is 40 minutes per week for each subject." [P1/PT2/App/010]*
> *"Usually is 3 times per week for each subject." [P1/PT5/App/010]*

Only one preschool teacher carried out both science and mathematics lessons daily for one hour each. As a result, compared to other core subjects, early science and early mathematics occupied a modest fraction of time allocation in preschool settings.

The setting of lessons refers to the location or place where the teaching and learning process takes place. The findings revealed that the majority of preschool teachers are extremely adaptable when it comes to organising settings based on subjects, such as inside or outside the classroom, in the field, at the multipurpose corner, science corner, or outdoor play area. However, there is an exception to this rule in the case of a structured teacher who limits her teaching and learning process to the classroom, as said, *"For me, the lesson conducted in the classroom only." [P1/PT5/App/014]*

In terms of science and mathematics teaching methods, the survey discovered that most pre-school teachers had successfully adapted to the methodologies proposed in the National Preschool Standard-Based Curriculum (NPSC) to fit into various sessions. Among the favourite approaches mentioned by preschool teachers, such as hands-on activities, play-based approach, thematic approach, and others, all the teachers preferred hands-on activities above all others because they found that this method can always bring pre-schoolers active learning that they love the most.

> *"I follow the approaches stated in the established curriculum, but surely using hands-on activities…ya." [P1/PT2/App/016]*
> *"I always apply the hands-on and play approach to teach maths and science." [P1/PT3/App/018]*

In the teaching and learning process, the teacher, as the knowledge deliverer, plays a critical role. According to the findings of the current study, the majority of preschool teachers find themselves serve as facilitators, assisting pre-schoolers in their learning process through observation, discussion, and encouragement in hands-on activities. In addition, pre-school teachers responded that they must constantly be prepared and able to create relevant and appropriate teaching and learning strategies to meet the needs of pre-schoolers in order to ensure that they are equipped with early mathematics and scientific ideas. For example,

> *"Teacher…like facilitator, we facilitate the children to learn." [P1/PT2/App/020]*
> *"Role in teaching…emm…I think teachers are to train the children with modern methods and techniques in learning science and mathematics concepts…" [P1/PT5/App/022]*

Teachers must consider teaching and learning materials when strategizing and maximising the impact of their lessons. According to the findings, preschool teachers used both existing resources and new teaching materials which they create and produce by themselves based on the needs of the lessons and the materials they created themselves. They advocated for the use of concrete objects in the teaching and learning process to foster real-world experience and the development of thinking abilities in pre-schoolers during the early mathematics and science learning process. Furthermore, the divergent materials employed would assist pre-schoolers to have more engaging lessons and focus their attention for active participation in their learning.

> *"Real objects right, it can provide real experience, children can touch, can feel…" [P1/PT2/App/024]*
> *"Materials…mmm…using computer, real materials…or concrete materials…yang kita panggil objek maujud la (we known it as real object)." [P1/PT4/App/028].*

In terms of the topics and content of early science and mathematics lessons, many preschool teachers followed the NPSC-designed syllabus. Most pre-school teachers strictly followed the NPSC syllabus when teaching early mathematics and science subjects. For instance,

"Based on the NPSC…separately to teach science and mathematics." *[P1/PT4/App/032]*
"No, no additional topics. All follow NPSC." *[P1/PT4/App/034]*

Simultaneously, there is also some teachers laid out many curriculum-related topics which are out of NPSC syllabus for preschoolers' better knowledge and comprehension, likely, *"Ada (Have)…some extra topics related with syllabus topics in KSPK (NPSC) pun ada ajar (also teaching)."* *[P1/PT2/App/030]*

Although the pre-school teachers above have emphasized on the latest approaches employed in delivering science and mathematics subjects to young children, they were encountering several barriers while planning the activities as discussed in the following themes.

Under the theme of science and mathematics learning for pre-schoolers, the five aspects that were investigated about the process towards acquisition of knowledge in these both subjects are: 1) effectiveness of current learning process; 2) problem in learning science and mathematics; 3) opportunities of effective learning; 4) suggestions for effective learning; and 5) favourite themes or topics for science and mathematics.

Based on the findings, all preschool teachers concluded that the current learning process used by pre-schoolers in accordance with the National Preschool Standard-Based Curriculum (NPSC) and the approach used is effective and meets the intended outcomes as outlined in the NPSC, but that there is still room for improvement to make learning more fun and effective for the children. They mentioned as following:

"Yes. Is suitable for the pre-schoolers' level." *[P1/PT2/SML/034]*
"Mmmm yes. But maybe need improvement to make children fun to learn effectively." *[P1/PT3/SML/034]*

The preschool teachers then disclosed that there were a number of issues with the preschoolers' science and mathematics learning. The preschool teachers stated that both early mathematics and early science learning faced language barriers due to the different backgrounds of the children, as well as a lack of resources such as instructional materials and modules in the response of *"Problem…mmm limited resources."* *[P1/PT4/SML/040]* Preschool teachers also reported that preschoolers exhibited little interest in mathematics and had trouble learning new terminology in science, who denoted *"Uhm…ya…Somehow, we lack materials for science subject. For math…well, the children sometimes are not interested to learn maths."* *[P1/PT5/SML/036]*

Despite the challenges of learning science and mathematics, preschool teachers observed that there are opportunities for preschoolers to learn science and mathematics efficiently, such as opportunities to be exposed to a variety of materials and environments. Sufficient teaching and learning resources, such as weighing scales and measuring tape, as well as a suitable learning environment, such as a laboratory in the classroom, are considered as enormous opportunities for children's effective learning. By providing opportunities, the pre-schoolers' enthusiasm, curiosity, and further exploration and their learning will be effectively maximised, as children have an insatiable desire to learn new things about the world. They explained:

"… if they have lab, everything, then is really very good for them. Because they really show their interest to want, to know something new." *[P1/PT1/SML/064]*
"…There is a lot of opportunities to learn effectively. As there is a various of teaching and learning methods being applied to better serve the children." *[P1/PT3/SML/040]*

To help pre-schoolers learn science and mathematics successfully, preschool teachers suggested to provide more related materials such as concrete objects, visual representations, and modules. Preschool teachers also suggested creating a variety of relatable and appropriate activities, such as grouping activities based on the children's ability for a higher level of hands-on learning.

"…more hands-on activities…project activities…and materials important …yang tu kena ada (that must have). …we need more teaching materials provide…" *[P1/PT2/SML/042, 044]*
"…use more concrete materials…and visual representations also, to develop deep understanding of the object." *[P1/PT3/SML/042]*

In the sense of preschoolers' favourite themes or topics in early science and mathematics learning, preschool teachers discovered a diverse range of themes and topics that the preschoolers favoured. Preschoolers' favourite

early science topics include magnets, float and sink, animal-related topics, green fingers, solar systems, and so on. Seriation, shapes, number sense, addition and subtraction, patterns, counting, and other mathematics themes have piqued the children's attention. Certainly, according to one of the preschool teachers, the children are interested in all things, regardless of the topics as emphasized in the utterances.

> *"The magnet, float and sink. … Mathematics, …counting,* ***…."*** *[P1/PT1/SML/090, 094]*
> *"Hmmm…animals bah, children love animals' topic. If maths …they like seriation." [P1/PT2/SML/046]*
> *"I think…no… just fine with all topics." [P1/PT4/SML/056]*

The third theme of the needs analysis for the STEAM approach in science and mathematics teaching in preschool which is the preschool teachers' understanding and awareness on STEAM approach were investigated. The four key subthemes identified in this context are: 1) awareness and understanding on STEAM; 2) application of STEAM approach; 3) affective aspect of using STEAM approach; and 4) training on STEAM approach.

The results revealed that preschool teachers are aware of the Science, Technology, Engineering, Arts, and Mathematics (STEAM) learning strategy, which is introduced following the STEM approach. Only one of the teachers has attended one of the school's STEAM seminars as informed, *"Yup, I have attended a workshop on STEM and STEAM organised by my school…and my workplace." [P1/PT3/AnU/052]*

While for the implementation of the STEAM approach in preschool settings, all preschool teachers agreed that it is appropriate to use this approach in the teaching and learning process because it helps to stimulate thinking skills, problem-solving skills, and holistic development among pre-schoolers through a variety of hands-on activities and experiments.

> *"… They want everything hands-on activities, moving on." [P1/PT1/AnU/122]*
> *"Ya agree. … good for their thinking skills." [P1/PT2/AnU/056, 058]*
> *"Oh this must be a yes, it's good for their holistic development." [P1/PT3/AnU/056]*

Following that, the preschool teachers discussed their experiences and feelings about applying the STEAM method in the classroom. Although some teachers find the STEAM approach innovative and demanding since it requires more thinking, such as, *"… I find it… quite challenging…also require a lot of thinking process." [P1/PT5/AnU/054]*, all teachers accept it positively in the teaching and learning process, likely, *"… it's kind of new approach, so we can really explore and expose to by using STEAM." [P1/PT2/AnU/062]*. It can enlighten children's curiosity and prolong their participation in the learning process. Nonetheless, the teachers advocated for hoping to have the developed module as a guideline.

Additionally, most of the preschool teachers stated that they had attended some basic STEM and STEAM approach workshops as said, *"… only half-day course for STEM, but they just like brief the teacher." [P1/PT1/AnU/144,146]*. While a few teachers admitted to not having attended or received relevant workshop or training. As a result, not all preschool teachers have received extensive training or workshops in the use of STEM or STEAM approaches, instead receiving only a cursory introduction.

The theme of pedagogical content knowledge in teaching explored the knowledge of the subject being taught and the way of imparting it. The aspects emerged under the theme included: 1) opinion on good lesson or activity; 2) effectiveness of current lessons; 3) difficulties encountered in teaching; 4) difficult themes or topics; and 5) suggestions for effective teaching.

Preschool teachers' opinions on a good lesson or activity were gathered for this study in order to gain a deeper pedagogical content knowledge in teaching early science and early mathematics. The preschool teachers discussed what they thought were good teachings and activities for the preschoolers. To provide children more opportunities to explore and experience the learning process, they must adapt their teaching methods and plan for hands-on, entertaining, and age-appropriate activities such as using child-centered and integrated play activities. Teachers' teaching strategies must be altered to offer better lessons for young children as children nowadays grow up in a rapidly expanding environment. This can be proved in their utterances:

> "*Mmm lesson with hands-on activities…give children more opportunities to explore…and play." [P1/PT2/PCK/068]*

> *"... I think it is more child-centred…able to let the children to explore and experience rather than just guiding them step-by-step." [P1/PT5/PCK/058]*

Under the aspect regarding effectiveness of current lessons, most teachers said that existing classes are effective but that they have yet to reach their full potential due to a variety of problems such as classroom management, limited resources, time constraints in material and activity preparation, a lack of variety of settings and knowledge wise. For examples, *"...because of... limited material…sometimes also limited time to teach…hmm limited resources to implement. ... my knowledge is less" [P1/PT4/PCK/076,078, 082]* and *"...I would say designing the activities that are fun, educational and at the same times not too overwhelming on the students is quite ...difficult." [P1/PT3/PCK/068]*. One teacher recommended a thematic approach, which is presently used in classes to nurture young children's enthusiasm in learning science and mathematics, to boost the productivity of current lessons.

Aside from teaching challenges, the study looked into tough themes or topics for preschool teachers to teach. Measurement, the water cycle, force, and electricity were among the early science topics that preschool instructors found challenging to teach since they required a higher level of expertise. While addition and subtraction, number concepts, time concept, space, geometry such as three-dimensional shapes, vertices, angles, and symmetry are early mathematics topics that they find difficult to impart in lessons, the children take time to understand the concept as some topics require abstract imagination as in the following extracts.

> *"Plus and minus…make the children sometimes confuse with the concept. Like that add in and take away." [P1/PT2/PCK/082]*
> *"…concept of time…space and time…" [P1/PT4/PCK/084]*
> *"…I think it is harder to teach number concepts…some take longer time to understand what numbers are." [P1/PT5/PCK/066,068]*

Another teacher expressed that the topics are not difficult, but she emphasized of limited knowledge in herself due to less exposure to the topics through trainings or courses in teaching the topics has led to the challenges.

All in all, the preschool teachers offered various suggestions for early science and mathematics teaching in the classroom to improve the effectiveness of teaching in terms of pedagogical content understanding. For instance,

> *"Attend more trainings, workshops…" [P1/PT2/PCK/086]*
> *"... Ah and also be an active observer. We must always keep tracking on children's development…interests…and then decide if the curriculum or lesson need to be modified or altered to better serve the children…" [P1/PT3/PCK/076]*

To improve the efficacy of teaching, the majority of instructors advocated having trainings, seminars, or workshops that keep them up to date on the latest information about the STEAM method. Furthermore, pre-school teachers mentioned that they have to be active and be a sensitive observer in the classroom so that they may identify the current needs of the pre-schoolers and track their development as well as the efficacy of the teaching method. Last but not least, application of electronic gadgets, providing more time and space for young children to investigate in the learning process, as well as the integration of play in early science and mathematics are suggested to improve the efficiency of the teaching and learning process.

DISCUSSIONS

To collect preschoolers' learning needs (Richards, 2001:51), the researcher has explored the needs analysis of STEAM approach on early science and mathematics teaching and learning in the preschool classroom settings. It has been investigated through the method used in typical lessons, science and mathematics learning for preschoolers, awareness and understanding of STEAM approach, and pedagogical content knowledge in teaching in this study.

The current study found that the preschool teachers follow the scheme that outlined in the curriculum through distinct learning areas such as early mathematics and integrated learning. As suggested in the National Preschool Standard-Based Curriculum, the preschool teachers mostly devote about 40 minutes to each early science and mathematics subject (MOE, 2017). Physical environment in education refers to educators' provision of appropriate spaces and facilities for children's activities (Mengmeng, Xiantong, & Xinghua, 2019), which plays an essential part in the learning process of children. The pre-school teachers in the study were able to adjust to diverse settings

when conducting classes, depending on the theme or topic for each lesson. This is supported by Diamond and colleagues (2013) that the adult's responsibility is to create "an appealing environment and respond to children's interests" while children are expected to learn through play. Current findings show that most of the time spent on the early mathematics and science lessons was in classrooms, multipurpose corners, and outdoor areas according to classes' needs. The findings are nearly identical to those of Zsoldos-Marchis and Ciascai (2019), who found that a minority of preschool instructors believe STEM/STEAM/STREAM activities must be arranged outside of school as typical school structures could be a barrier for STEM Education (Margot & Kettler, 2019).

The current preschool science and mathematics teaching techniques in terms of teaching approach, teachers' roles, instructional tools, and the content was discovered to be organised, with little room for freedom in light of data collected. The teaching method and lesson content were strictly adhered to in accordance with the syllabus in the National Preschool Standard-Based Curriculum (MOE, 2017). Teachers play a vital role in STEAM integration teaching and learning as facilitators (Hadinugrahaningsih, Rahmawati & Ridwan, 2017). Despite the fact that the majority of preschool teachers are aware of their role as facilitators, the general situation still shows that preschool teachers act as "mere technicians" (Takaya, 2008), conveying the prescribed contents of early science and mathematics from the curriculum to pre-schoolers rather than facilitating their own explorations of the world. According to Diamond et al. (2013)'s research on science and mathematics lessons, learning gains are lower when there is more teacher guidance and direction. Thus, preschool teachers must be trained to think outside the box and develop engaging lessons with a variety of activities based on the interests and learning abilities of the children besides following the approach and contents in NPSC (MOE, 2017) rigidly. As Cremin, Glauert, Craft, Compton, and Stylianidou (2015) mentioned in their study that preschool teachers rarely consider creativity when preparing and executing lessons.

In the field of education, the curriculum is a crucial reference in the teaching and learning process (Elliazah, 2020). According to the participants of the study, the current teaching strategy based on the National Preschool Standard-Based Curriculum (NPSC) is effectively implemented for science and mathematics learning among preschoolers. However, one participant stated that the current motions may be too complex for preschoolers as young as 4 years old, while another pre-school teacher advised to improve these approaches in order to give an engaging and effective learning experience. It is in line with the findings of Mura, Velllante, Nardi, Machado, and Carta (2015), who found that the environment of pre-schools and teachers' approaches can influence children's participation in classroom activities. In addition, the study also revealed a series of science and mathematics topics which young children favored throughout the teaching and learning process. As according to DeJarnette (2018), children are naturally drawn to STEAM topics because they like exploring and experimenting in their natural surroundings.

The preschool teachers included several issues such as a lack of materials or resources, as well as a lack of room for a broader exposure to more learning opportunities. These variables are congruent with Dogan and Simsar (2018), who identified the same obstacles that limit the implementation of early science activities, as well as Moomaw (2011) in Maths-oriented activities. Another researcher looked at how preschool spaces are built and used as a source of pedagogical materials to support children's learning and interaction (Mamat, Razalli, Hashim, Ahmad & Awang, 2018; Majzub, 2006). Upon this issue, the participants recommended to create a module, to conduct assorted hands-on activities as well as apply diverse teaching aids for pre-schoolers while they are learning early science and mathematics to improve the learning effectiveness. As providing a series of joyful yet educational learning experience for preschoolers, play and hands-on learning approaches have proven to be effective as new ways of teaching science and mathematics (Obaikor et al., 2019). Compared to traditional learning approaches, studies have also demonstrated that hands-on active learning, movement, and play-based education have favourable effects on student learning outcomes (Bodrova & Leong, 2005; Hunter-Doniger, 2019; Wang & Lieberoth, 2016) which are similar to the respondents' recommendation. In this context, the preschool teachers' opinion through the needs analysis phase regarding the integration of play-based activities with STEAM approach in the preschool settings have given support to the STEAM module designed with assorted play-based activities. Therefore, it is possible to suggest that the use of STEAM does give a positive aspect of hands-on active participation of preschoolers.

STEAM, as defined by the preschool teachers, is the integration of strands throughout the learning process, which includes the element of science, technology, engineering, arts, and mathematics. This is consistent with the findings of Brown, Weber, and Yoon (2015), who found that early childhood educators saw STEAM as an add-on to novel techniques rather than a tool to help students meet learning standards. This is as well supported by the study by Jamil, Linder and Stegelin (2018) where all participants viewed STEAM as a task-oriented approach and a separate set of content for children to learn rather than a mechanism for combining education. In this context, all preschool

teachers agreed that this novel method to science and mathematics teaching should be used since it has the potential to increase pre-schoolers' enthusiasm in learning while also stimulating their thinking skills. According to Sharapan (2012), the STEAM method is marketed as a tool to aid pre-school teachers in creating a foundation of scientific and mathematics related knowledge by integrating arts to inspire young children to represent their ideas in a creative medium. On the other hand, Mengmeng, Xiantong, and Xinghua (2019) as well emphasised that STEAM learning has been identified as a key lever in the advancement of high-quality preschool education for all children.

Next, the needs for teacher training on STEAM approach in teaching science and mathematics has also been illuminated in the current study. These findings resonate with several studies highlighting pre-school teachers lack competence and skills in teaching science and mathematics by integrating various approaches, likely STEAM and play based (Bequette & Beqquette, 2012; Nilsson, 2015; Sharifah & Aliza, 2012). As suggested by Jamil, Linder and Stagelin (2017), the pre-service and in-service development trainings are the necessary avenue for equipping the teachers to meet the needs of young children who thrive in a rapidly evolving and complex community. In DeJarnette (2018) study, all workshops offered are hands-on and STEAM model lessons for the teachers and the findings demonstrated the teachers' self-efficacy increased significantly as a result of the workshop, provided resources, and modelling of STEAM activities. So, participation in training courses increases teachers' self-confidence to plan and implement STEAM lessons and it develops a more positive attitude towards integrating STEAM in their teaching (DeJarnette, 2018; Mustam & Adnan, 2019). Thus, providing preschool teachers with STEAM workshops and trainings to update themselves on better ways to organise, conduct, and integrate this approach in the teaching and learning process of early science and mathematics, as well as their teaching confidence, will be extremely advantageous. As teachers' understanding, implementation of activities, use of teaching materials, and personalities of teachers all contribute to a more engaging teaching and learning process (Masran & Ismail, 2016).

The participants rated their current teaching pedagogy as effective, although they felt that more hands-on activities, an enjoyable learning process, and developmentally appropriate activities were needed. The findings of the study are aligned with the study conducted by Charsky and Ressler (2011) which conclude that fun learning is critical in preparing pre-schoolers to learn in an interactive and engaged learning environment. STEAM activities can give a plethora of learning opportunities for preschoolers while also supporting them in the development of problem-solving skills as children's hands-on exploration is fundamentally a continuous problem-solving activity (Mengmeng, Xiantong, & Xinghua, 2019). In other words, it is conceivable to argue that the STEAM approach is an instructional strategy for allowing young learners to be innovative and problem solvers in order to meet problems (Ceschini, 2014; Rich, 2010; Sharapan, 2012).

In the current research, insufficient of teaching aids, limited resources, environment and time, inadequate of related pedagogical content knowledge, as well as the numbers of children and their different developmental level are the major challenges towards the implementation of effective teaching. This finding is supported by Clipa and Boghean (2015) who has indicated that the teachers encountered numerous of stress sources where the large children's groups on a reduced space, with no utilities, accessories and adequate teaching materials to meet their needs throughout the teaching and learning process. Similar to Zsoldos-Marchis and Ciascai's (2019) study, which found that two-thirds of preschool instructors said it's difficult to create an integrated STEM/STEAM/STREAM activity.

In light of the rigidity in today's classrooms (Trundle, 2015) in terms of teaching pedagogy, learning area and so on, findings revealed the need for increased flexibility in early science and mathematics teaching and learning. Tee (2015) has advocated that local early childhood education be revamped in the area of expanding pedagogical flexibility. To improve teachers' awareness of the STEAM method, they must be encouraged to continue their professional development in perceiving relevant practices in order to provide successful instruction (Herro & Quigley, 2017). To interest preschoolers in studying science and mathematics, the researcher attempted to design and construct an instructional tool by combining play-based activities with STEAM approach. As Jamil and colleagues (2017) point out, STEAM provides a framework for conceptualising and implementing instructional practices that are particularly relevant for the development of young learners. Last but not least, STEAM-based learning planning is critical for assisting children in realising their full potential, ensuring the implementation of relevant and high-quality learning, and encouraging children to explore their strengths in their own unique way (Ellizah, 2020).

CONCLUSION

This article discusses the conceptual aspect of the study, the importance of STEAM as well as what STEAM contributes to the learning process when STEAM approach is introduced into the right situation, place and time, towards pre-schoolers' learning process. Either the "A' is magical, or 'STEM" is magical, it is the delivery of the science and mathematics learning process with the appropriate STEAM approach that matters. With the information gathered from the needs analysis for the STEAM approach in science and mathematics teaching in preschool classrooms, the researcher attempted to create and construct an instructional tool that combined play-based activities with a STEAM approach in order to entice pre-schoolers to learn science and mathematics.

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