

Assessing Preschool Teachers' Challenges and Needs for Creativity in STEM Education

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Abstract: Creativity in teaching is important in order to ensure children are engaged in learning Science, Technology, Engineering and Mathematics (STEM). However, previous research has claimed creativity in learning STEM for children is not adequately supported by teacher in classroom due to the lack of preparation, content knowledge and skills. This study aims to assess the needs and challenges of promoting creativity in STEM education. In this study, preschool teachers (n= 22) were interviewed as they are the key informants who are involved in STEM education. The semi-structured interviews were analysed using qualitative content analysis and were qualitatively coded. Results illustrate that there are several distinctive themes identified as described by the participants when discussing the needs and challenges of implementing integrated creativity skill in STEM education as well as the support that would be most helpful in overcoming them. The results highlighted a huge gap between creativity knowledge and the implementation of creativity in STEM education. Participants also provided specific support needed to integrate creativity in STEM education. Preliminary findings suggest that many teachers are interested in integrating creativity skills in STEM education. This research sheds light on the needs and challenges for professional pre-school teachers by providing them pedagogical module as well as professional training to promote creativity in teaching STEM

Keywords: Creativity Skills, Needs and Challenges, STEM

1. Introduction

In recent years, numerous researchers worldwide have focused on Science, Technology, Engineering and Mathematics (STEM) education. This is because of the importance of STEM knowledge and skills for contemporary education, future career and life. In the next few years, more jobs will demand workers that possess knowledge and competency related to STEM (Chubb, 2013). Hence, it is essential that STEM education is embedded into the learning of all levels, including in the early years at school. Chesloff (2013) strongly supports STEM education to be introduced into early childhood education because "Young children are natural-born scientists and engineers".

Taking into account what is stated by Chesloff (2013), an important inquiry is raised: How do young children acquire STEM concepts that are considered difficult by adults? It is achievable through

the engagement in various processes during children's exploration of the environment such as observing and exploring the concepts of force, motion, ecosystems, numbers and shapes that young learners learn to understand the world around them and acquire vital skills for everyday life. As observed by researchers investigating STEM practices in pre-schools across three Australian states, children experienced STEM both inside and outside of the preschool setting; whereby even the informal settings (such as parks, beaches and forests) offered children rich opportunities to explore STEM concepts (Campbell et al., 2018). Furthermore, students' engagement in engineering processes including 'Ask, Imagine, Plan, Create, and Improve' can help familiarize students with the critical processes that engineers employ at work. Previous research acknowledged children as young scientists, young engineers, young mathematicians and young technologists. They are capable of inventing new ideas, solving problems, and making meaning of the world around them. Hence, it is important that STEM education is promoted in the early years of school. Ong, Ayob, Ibrahim, Shariff & Ishak (2016) proposed STEM education to be introduced to children as young as 3 years old to nurture them with STEM knowledge and skills.

The major concerns of STEM which were highlighted in previous researches state that STEM education is difficult, abstract and boring (Conradty & Bogner, 2019) and that 'STEM subjects do not score well when it comes to overall student engagement and engaging students' (McWilliam & Taylor 2016). This critical issue is mainly related to teacher factors. STEM educators were reported to employ traditional teaching that focused on a teacher-centered approach. This requires a change among teachers to switch to student-centered learning and employ STEM lessons to enrich the students and pique their interest. As suggested by Marbach-Ad, Ziemer, Orgler, & Thompson (2014), the improvements required include enhancing the 'quality of the entire education experience', 'teaching and learning' and 'learning engagement'. Hence, this calls for a student-centered approach that integrates creativity to be practiced in STEM classrooms. Furthermore, a multidisciplinary lesson that integrates creativity may help to enhance STEM learning and make the lesson more enjoyable and meaningful to the learners. Furthermore, a multidisciplinary lesson that integrates creativity may help to enhance STEM learning and make the lesson more enjoyable, meaningful to the learners and replace a traditional, teacher-led art classroom (Mohd Hawari, & Mohd Noor, 2020).

2. Research Background

Creativity, critical thinking skills and problem-solving capabilities are three critical skills required to prepare students for future life and career success (Kubat & Guray, 2018). Sternberg & Lubart (1999) defined creativity as involving a process, product and idea that are accessible to others and have the criteria namely: i) novelty or originality and ii) usefulness or value within a particular field (Beghetto, 2013; Pollard, Hains-Wesson & Young, 2018). Research reported that teachers seldomly promote critical thinking into young children's educational settings when young learners have the capability to construct STEM concepts (Gallenstein, 2003). Conradty and Bogner (2019) promoted the importance of providing students with the opportunity to imagine, explore, experiment, test, manipulate, take risks, speculate and to be allowed to make mistakes. Furthermore, Pollard et al. (2018) suggested the element of surprise (such as using songs) as vital aspects in STEM creative teaching.

Research has established the positive impact of creativity in STEM education (Hamid & Kamarudin, 2021; Ramli, Talib, Hassan & Manaf, 2020). Henriksen (2014) asserted that the integration of creativity into STEM classrooms has the potential to enhance STEM learning by encouraging creative solutions. Furthermore, creative learners affirm the process of discovery as an enjoyable experience (Csikszentmihalyi, 2015), especially during scientific investigations. This, in turn, leads to a deep understanding of scientific information such as the knowledge about nature and human as well as the development of students' awareness in relation to the individual role to protect nature (Jeong, S., & Kim, H. 2015; Hageman, et al., 2019). Activity such as creating sea corals diorama have the potential to help students obtain knowledge about coral reefs' population and its ecosystem by connecting newly learned knowledge and their previous experience. As asserted by Zhbanova, Rule & Tallakson (2019),

creating dioramas is a powerful educational tool that enhances various skills including spatial awareness, inquiry, critical thinking and creativity. Additionally, using songs, music, drama, and flipped classroom (element of surprise in learning) were evident in helping tackle students' anxiety including feeling uncomfortable, unsettled and 'freaked out' when learning STEM subjects (Lynch K, et al., 2019). Evidently, creative instruction had resulted in active participation and engagement among students in learning sessions. The study by Conrady & Bogner (2019) exhibited that the integration of art into STEM lessons helped students gain scientific knowledge, increased their motivation to learn science and provided students with the opportunity to express themselves in creative ways and gain new knowledge. In addition to activities structured by teachers, creative play outside the classrooms that engaged children with exploration of the environment was also found to enrich STEM knowledge (Campbell et al., 2018).

While creativity can enhance STEM learning in various aspects, STEM education indeed fosters creativity among students. As clarified by previous researches (McWilliam, Poronnik & Taylor, 2008; Marquis & Vajoczki, 2012), STEM instruction that employs student-centered approach has the tendency to encourage creativity. Stylianidou et al. (2018) highlighted that STEM learning which emphasizes on experiential learning has positively impacted students' creativity by means of encouragement from the teachers to the students by asking questions and being curious (important exploration process emphasized in STEM learning). Strategies such as providing a nurturing environment, enriching the curriculum and assigning students with responsibility and cognitive scaffolding as well as providing reinforcement and encouragement are suggested practices that can enhance creativity in STEM learning (Shen & Edwards, 2017). The opportunity to investigate various phenomenon surrounding them help students become creative problem solvers in offering creative solutions.

The important role that teachers have to play is to effectively and creatively implement STEM instruction in their classrooms. This role has posed a great challenge to most teachers as teachers are required to be knowledgeable and skilful in both STEM and creative aspects. Limitations in teachers' competence to foster creativity in STEM lessons for pre-schoolers have been reported. Previous research highlighted that teachers lacked STEM and pedagogical knowledge, had low self-efficacy and confidence to teach STEM areas (Campbell & Jobling, 2010; Edwards & Loveridge, 2011) and lacked the skills in promoting creativity in learning (Greenberg & Walsh, 2008). Additionally, the switch from the traditional teaching approach to creative teaching in STEM is not an easy process as educators simply felt comfortable and familiar with the former teaching practice (Stylianidou et al., 2018). In addition to personal struggle, obstacles towards changing to creative STEM teaching include receiving limited support from colleagues. Furthermore, teachers found creative teaching troublesome and they face several challenges including lack of time, space and budget as well as curriculum constraints (Stylianidou et al., 2018). In addition, teachers received limited support to employ creativity-driven lessons by means of student-teacher discussions and collaborative work. Also, the education policy lacked the details on how creative STEM teaching and learning should be planned and carried out by teachers. For example, despite highlighting the importance of integrating creativity in the policy, Stylianidou et al. (2018) found that most education policies at nine European countries lacked references to aspects of creativity that could be promoted through both conversation and collaboration in STEM learning. Hence, in order to employ creative STEM education effectively in classrooms, changes should be made with reference to practices and related documents including curriculum, pedagogy and assessment to foster creativity in learning and teaching (Stylianidou et al., 2018). Although research has reported that teachers lacked knowledge, skills and confidence in promoting STEM education (Campbell & Jobling, 2010; Edwards & Loveridge, 2011; Greenberg & Walsh, 2008), previous studies

has not reported on the creativity aspect in promoting STEM education. Hence, this study focused on the teachers' understanding about creativity and the challenges that they faced in promoting STEM lessons.

3. Methodology

This research used qualitative approach which focussed on ground-up approaches in the constructivist paradigm. This method was designed with the aim of exploring teachers' understanding of creativity skills in STEM lessons and challenges faced in embedding creativity skills in teaching STEM. Participants were required to elaborate on their understanding and challenges when integrating creativity skills in teaching STEM. In this study, researchers interviewed respondents which were among the novice and senior teachers as well as the pre-school principals by using the following questions:

1. What do you understand by creativity skills in STEM lessons?
2. What are the challenges faced in order to instil creativity skills in teaching STEM at pre-schools?

Based on the descriptions obtained from the participants regarding creativity skills in teaching STEM, a pattern was identified. Then, the researchers synthesised the explanation and discussion into coding categories for analysis.

3.1 Informants and Procedures

Ethical approval for the study was granted by the institutional research ethics committee. A total of 22 pre – school teacher (fifteen senior teachers and seven novice teachers) were selected as the research participants in this study and they gave a written consent to take part in the study. From this number, twenty of them were female (90 %) and two of them were male (10 %) and all of them were involved in lessons related to Science or Mathematics. Besides that, participants' age ranged from 25 to 42, with an average age of 28 years old. Participants were geographically distributed around Malaysia. Purposive sampling was used to select participants for the semi-structured interview. The researchers were particular in selecting the research participants by considering the education background of the pre-school teachers; only taking in those who have a certificate in early childhood education. This is to ensure that the teachers genuinely understand the needs and challenges that they faced when teaching STEM.

Research participants were people who are involved with creativity program in STEM education for pre-schoolers This program is a networking collaboration between Universiti Kebangsaan Malaysia and the pre-school teachers which is funded by Universiti Kebangsaan Malaysia. There are two phases in this program. In the first phase, researchers obtained input from the informants regarding their understanding on creativity in STEM and the most vital needs to integrate creativity skills in STEM education at the pre-school level. This is a significant phase to explore the challenges faced and teachers' needs so the researchers can frame a module to address the input and enhance creativity in STEM education. Whereby in the second phase, the researchers focussed on establishing a well-adapted module to integrate creativity skills in STEM education at pre-schools.

3.2 Data Collection

Researchers used semi-structured interviews as the primary data source. Interviews have several advantages in a needs assessment study which include providing in-depth information on a broad range of topics, allowing for the explication of ambiguous responses, and eliciting more information than is possible through group methods. Interviews can serve as a useful starting point for the construction of questionnaires by identifying potential issues for further investigation (Nagle and

Gagnon 2008). Researchers conducted the research in two weeks and used semi-structured interview method to collect data. The semi-structured interview suits this research and has several benefits such as its ability to find a clear and in-depth data about the topic discussed and it lessens the probability of repetition in information obtained from each participants. Semi-structured interview is intended to obtain and further explore the information from informants.

In this research, participants were interviewed for 25 to 45 minutes individually and the challenges and the needs to integrate creativity in STEM education were discussed. We utilized the same interview protocols for the novice and senior teachers. Two experienced researchers conducted interviews using the same interview protocol that applied to all pre-school teachers. The interview began by asking participants about their understanding on creativity skills, STEM education and how they define creativity skills in STEM education. This established a baseline of teacher understanding of embedding creativity skills in STEM teaching. Next we also asked the challenges or barriers to achieving integrated creativity skills in STEM education. We also asked about the supports that the teacher need in order to integrate creativity skills teaching STEM.

3.3 Data Analysis

In this research, researchers analysed the data obtained from the semi-structured interview. This is meant to determine the themes as required in qualitative data analysis (Creswell, 2007; Denzin & Lincoln 2005). The recorded focus group discussions were randomly assigned to two researchers who acted as the coders. Using grounded theory approach, researchers developed and highlighted the themes systematically (Glaser & Strauss 1967). The first step is to identify the important elements by creating concepts, analysing and categorising the data carried out by the coders in details. All coders generated categories and elaborated them further. This led to selective coding in which we determined essential and core categories; consolidating some codes into central and comprehensive codes. Preliminary codes were often idiosyncratic to a single interview. For instance, an informant identified “What do you understand by creativity skills in teaching STEM” as exploring their knowledge and understanding in instilling creativity skills in teaching STEM. The final results from the coding can be seen in Table 1. Researchers allowed for double coding which means that more than one topics could be identified as discussed by group members. Twenty-five percent of the manuscripts were coded by two coders to estimate interrater reliability. Inter-rater agreement was 90% and Cohen’s Kappa (which takes into account the rate of random agreement) was 80, which is in the acceptable to good range.

4. Findings and Discussion

Table 1. Coding categories and frequency of each theme from the research questions.

FOCUS GROUP DISCUSSION
Definition of Creativity in STEM
Created an innovative invention in teaching (12 out of 22, 54%)
Conducted problem-based learning (10 out of 22, 45%)
Planned a unique activity, thinking out of the box (4 of 22, 18 %)
Challenges to integrate creativity in STEM
Lack of knowledge about creativity in teaching STEM (21 of 22, 95%)
Lack of training and professional development (17 of 22, 77%).
Lack of time for planning (15 of 22, 68%).
Lack of finance (14 of 22, 63%).
Support needed to integrate creativity in STEM
Pedagogical short course (22 of 22, 100%)
Creativity STEM Module (20 of 22, 90%)
Mentor for guidance (20 of 22, 90%)

Financial resources (18 of 22, 81%).
More instructional time (15 of 22, 68%).

4.1 Teachers' understanding of creativity in STEM learning

To begin the data collection, researchers explored teachers' understanding towards the definition of creativity in STEM education among preschoolers. Thematic and frequency analysis on creativity in STEM show that creativity skill in STEM is an effort to create and invent an innovation (12 out of 22, 54%). It means that in order to create a novel invention, STEM educators require skills to generate ideas that can facilitate children to stimulate their creative mind. Acknowledging the limitation in children's cognitive to generate new ideas, research participants stated that idea generation demanded practical steps so that the children can experience a meaningful learning. This could help the children to have a better preparation in constructing knowledge based on experience and current knowledge. As suggested by Shen and Edwards (2017), teachers' scaffolding in the form of providing practical steps will encourage creativity in STEM learning. In addition, research participants also defined creativity skills in STEM as the teachers' ability to stimulate students in problem solving tasks (10 out of 22, 45%). Exposure to various kinds of problem-based tasks in STEM education drove children's thinking towards different alternatives. This exposure assisted the children to adapt themselves to situations that can enrich cognitive processing for creative thinking. Furthermore, relevant problems offered to the children during the activity will increase their engagement in STEM learning (Herro, Quigley, Andrews, & Delacruz, 2017; Campbell, Speldewinde, Howitt, & MacDonald, 2018). Interestingly, there were a number of participants who explained that in order to think creatively, teachers should facilitate the students to think uniquely or to think out of the box (4 out of 22, 18%). An emphasis was given to different ideas to what makes an individual more critical to take holistic perspectives and compare and contrast. The results revealed that creativity skills helped children to explore and experience meaningful learning that stimulate children to think and solve problems.

4.2 Challenges to integrate creativity skills in teaching STEM

The purpose of Science, Technology, Engineering and Mathematics education (STEM) is to develop and enable children's potential and creativity. However, there are several shortcomings experienced by the teachers to integrate creativity skills into STEM teaching at pre-schools. Results reported that most pre-school teachers stated that they have a lack of knowledge about creativity in teaching STEM (21 out of 22, 95%). It means that the teachers do not possess the adequate knowledge regarding creativity which made it difficult for them to integrate creativity elements that could stimulate children's creativity skills in the lessons. This challenge led teachers to focus more on the subject-content in STEM. In fact, teachers also reported that there is a lack of training and professional development that focuses on creativity skills in STEM (17 out of 22, 77%). This findings are in lined with DeJarnette's (2018) study who argued that middle and high school teachers are specifically trained within their STEM disciplines, however at the elementary and early childhood level, teachers have had little training or no instruction. Typically, training and professional development are held by the schools and education department to empower STEM teaching at schools. Nonetheless, according to four principals and two education officers, courses that were previously organized did not put much emphasis on instilling creativity skills in STEM education. This is one of the obstacles to integrate creativity skills in STEM education which compels teachers to focus more on the subject content.

Furthermore, the other factors such as the lack of time for planning (15 out of 22, 68%) and lack of finance (14 out of 22, 36%) are hurdles to the integration of creativity skills in teaching STEM. According to four pre-school principals, the number of students in a class ranged between 25 to 30 students and there are many subjects and activities that needed to be planned. It increased the workload of the teachers to plan activities that instil creativity skills in STEM lessons. The situation worsened due to the time spent at school typically lasted for 3.5 to four hours causing teachers to have less time to implement creativity-enriching activities since they also had to follow the schedule fixed for the syllabus. Meanwhile, financial constraint limited the ability to integrate creativity skills in teaching

STEM since teachers had limited expenditure for appropriate learning aids for STEM lessons. Teachers reported that most activities in STEM classes were mainly colouring, writing and drawing preventing the students to be engaged in hands-on activities since they were constrained financially to equip the lessons with proper tools. These findings indicate that the ecosystem in term of financial support and time allocation for STEM teaching and learning is as important as professional development for teachers. This finding is in lined with Hutchison's (2012) study that argued financial support is one of the necessary components for development and to sustain STEM teaching and learning.

4.3 Support needed to integrate creativity skills in STEM education.

In this research, researchers ask the question; “What are the kinds of support needed to help teachers to instil creativity skills in teaching STEM?” Pre-school teachers reported that they required a short pedagogical course (22 out of 22, 100%) which aims to increase teachers’ knowledge and skills to deliver lessons in classrooms. In this context, teachers hoped that they received more exposure on creative skill teaching strategies that can be utilized in STEM education. Besides that, teachers also asserted that they would find STEM-Creativity Module helpful as a guide to implement learning activities (20 out of 22, 90%). This module could assist teachers to employ effective lessons since the established module will integrate creativity elements in teaching and cut the preparation time in planning activities. Moreover, teachers also explained that they needed a mentor for guidance to ensure that the integration of creativity skills in teaching could be practiced (20 out of 22, 90%). The pre-school teachers in this research have the education background and experience in the pre-school education, however, they require mentors that can give advice, supervise and evaluate the teaching process to achieve the intended objectives.

On top of that, pre-school teachers stated that an extended financial resource was one of the supports that they needed in order to purchase appropriate teaching materials for the lessons (18 out of 22, 81%). Nevertheless, four research participants acknowledged that they did not have an issue with financial sources because they received financial aids from the parents who supported the learning enrichment for students at school. These financial aids helped teachers to fulfil the requirement for efficient STEM lessons in the classrooms. Apart from that, teachers mentioned that they were also in need of more instructional time in teaching STEM (15 out of 22, 68%). In reality, there is insufficient instructional time at schools when compared to the amount of syllabus that needed to be delivered to the students. This limitation has led to a disproportionate focus given to the content rather than the creativity elements in teaching STEM.

The findings about the challenges and support needed by the teachers are in lined with DeJarnette's (2018) study. She suggested providing hands-on professional development courses, consistent support, and rich resources for STEM lesson implementation into the early childhood curriculum. By doing so, it would impact the dispositions, self-efficacy, and rate of implementation for teachers (DeJarnette, 2018)

5. Suggestions

5.1 Teachers Professional Development

The results of this research showed that professional development for teachers’ education is an essential need required by the pre-school teachers. It means that the authorities such as the Ministry of Education, teacher education institutions and universities should provide training or courses that can empower the teachers to instil teaching creativity skills in STEM learning. There are two important aspects that should be considered in making sure this effort becomes a success which are reinforcement of knowledge in STEM and creativity as well as the integration of creativity skills in teaching STEM. In other words, the training or courses should not only encourage the dissemination of knowledge but also strengthening teachers’ skill in delivering lessons. This can narrow the gap between knowledge and skills for teachers to improve their teaching practices in STEM education at pre-schools. Moreover, strong, sound knowledge and skills encourage teachers to collaborate with each other to tackle

challenges and failures productively. Therefore, teacher professional education which trains the teachers to hone creativity skills in teaching STEM should be finalised further to ensure the pre-school teachers experience a comprehensive and systematic processes in delivering STEM lessons.

In general, pre-school teachers explained that the implementation of creativity skills in pre-school STEM education did not receive enough attention and were not fully practiced in their teaching. Results revealed that most teachers fell far behind in integrated STEM teaching standards since they were unable to imagine the application of creativity skills in teaching STEM. This is a huge barrier in ensuring the implementation of STEM teaching practices. This research highlights that the knowledge to cultivate creativity skills in STEM pre-school education has a gap that affects teaching practices. Most teachers admitted that they did not have adequate knowledge about standard practices to instil creativity skills other than the content of the STEM subjects.

The integration of creativity skills in a proper and organised STEM teaching shall require all the supports the teachers have to enhance their knowledge and teaching practices at classrooms. Pre-school teachers who are involved with creativity skills in STEM workshops will be taught and provided with hands-on experience until they understand and can integrate creativity skills in teaching STEM efficaciously. In general, the interviewed pre-school teachers were motivated to move towards understanding how creativity skills could be applied in classrooms, yet they needed guidance and collaboration from mentors who could be a source of reference to develop their professionalism in teaching. Thus, these challenges to integrate creativity skills in STEM education should be looked into so that the skill could be benefited to expand children's creativity in learning STEM.

5.2 Module Creativity STEM

This article discussed both phases, explored and evaluated the needs and challenges in integrating creativity skills in STEM. The results from the interviews were used to establish a module that addresses the challenges and teachers' needs to implement a teaching that cultivates creative skill in STEM. This module is an initiative to help teachers to deal with the challenges that they faced. The module integrates creativity skills in STEM holistically. In fact, the STEM-Creativity Module systematically encompasses creativity skills and elaborates clearly the implementation processes either in video or audio recordings so the pre-school teachers could conveniently benefit from it. This guides the teachers to evaluate their teaching and current practices in classrooms. Hence, the results of this study and the conclusion derived are deemed as a kick start towards creating a teaching module to cultivate creativity skills in STEM at pre-school level.

6.0 Conclusion

This research aims to explore pre-school teachers' understanding of creativity in STEM, challenges to implement creativity in STEM teaching and the support needed. The findings from this study revealed the pre-school teachers have grasped the understanding of creativity in STEM teaching and learning. Furthermore, the identified challenges and support needed to teach creativity in STEM in this study suggest that the ecosystem that consist of professional development, mentoring, teaching and learning resources, financial support, and sufficient time allocation are important catalysts. As a conclusion, the national education aspiration which currently focuses more on STEM education especially at the level of pre-schools will be urged to address the challenges and the relevance to extend and implement STEM curriculum and teaching. However, as a part of this tremendous effort, teachers should also be creative to deliver lessons to the children so that they develop an interest to explore STEM learning. Early exposure regarding learning STEM at the pre-school level is an essential step to bring about the children's scientific thinking skills. Therefore, in order to encourage the growth of knowledge and interest among students, creative thinking skills should also be woven in STEM learning. This is because creative thinking is important for science curricula and contemporary educational atmosphere. Integrating creative thinking into STEM may support project-based learning and inquiry-based learning as the creative catalyst, hence providing students with vital skills for both future learning and life.

The results from both the first and second phases lead the further exploration to understand teachers' needs and challenges to provide a relevant lesson based on the children's cognitive development. This research discussed the identified themes from the interview sessions with 22 pre-school teachers. The second phase enables the researchers to establish a module that cultivate creativity skills in STEM which shall be relevant and suitable according to the points made in the first phase. This module that is intended for pre-school teachers could be used as a basic guideline to teach in a more effective classroom. Research in creativity and STEM education is an effort to extend future research in understanding children learning development in STEM.

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