The Eurasia Proceedings of Educational & Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2016

Volume 4, Pages 336-341

ICEMST 2016: International Conference on Education in Mathematics, Science & Technology

INTEGRATING STEM INTO EARLY CHILDHOOD EDUCATION: IS IT FEASIBLE?

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ABSTRACT: This paper aims to determine the feasibility of integrating STEM into the early childhood education. As such, a survey design was deemed appropriate. Purposive sampling technique was used in which 22 early childhood teachers from 19 urban and rural childcare centres in Malaysia were selected for this study. These 22 early childhood teachers were familiarised to the use of **P**roblem-Based **I**nquiry **L**earning (PIL) in integrating STEM by means of 10 authors-developed STEM Projects through a three-day fully residential training workshop. Upon the completion of the training workshop, the teachers were supported in integrating STEM in their respective classrooms for five-month duration during which, an implementation of a maximum of five STEM Projects was aspired. Two sources of data were gathered from the teachers to determine the suitability of STEM integration in early childhood education: (1) at the end of the training workshop where teachers reported on the suitability of the STEM Projects for early childhood pupils aged 3 to 4+, and (2) at the end of the five-month classroom implementation where teachers reported on the STEM Projects which they have carried out with their 3-4+ year-old children. Findings indicated that, while two of the 10 STEM Projects were perceived as less appropriate by at least 50% of the teachers, eight other STEM Projects were deemed as appropriate. The actual implementation of STEM Projects among the teachers ranges between 60% to 100%, with a mean of 81%. This paper ends with a discussion on the characteristics of the appropriate STEM projects for 3 to 4+ year olds, and equally, implications for STEM education are proffered.

Key words: Project-based inquiry learning, STEM education, early childhood education

INTRODUCTION

Given the importance of science education in meeting the challenges and demands of our present and future economy, Malaysian government instituted the 60:40 Policy in 1967 -- 60% of students participating in Science/Technical while 40% in Arts. This is crucial because the National Council for Scientific Research and Development estimates that Malaysia needs 493,830 scientists and engineers by 2020 (Azian, 2015). Nevertheless, such aspired ratio has just yet to be met. Statistics indicate that, as of 2014, only about 45% of students graduated from the higher secondary schools were from the Science stream, including technical and vocational programmes. Moreover, the percentage of secondary school students who chose not to pursue the

- Selection and peer-review under responsibility of the Organizing Committee of the conference
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Science stream despite meeting the requirement based on their Form 3 National Standardised Examination (PMR) had increased to approximately 15% (Azian, 2015).

The dismal uptake of science-based subjects is rather pervasive across the globe. Taking United States of America (USA), for example, the National Science Board [NSB] (2010) reports that the numbers of USA high school graduates choosing to pursue a STEM-related field has declined steadily. In overcoming such decline, the NSB (2010) recommends that research-based STEM preparation should be provided for general education (elementary) teachers in the area of pre-service training and professional development, and that early exposure to STEM opportunities and the opportunity for students to engage in inquiry-based learning should also be provided to all students. Hence the current interest in promoting STEM (Science, Technology, Engineering, and Mathematics) which was introduced by the National Science Foundation (NSF) in the 1990s (Bybee, 2013).

Research indicates that the development of science talent begins in the early years and as such, the science proneness among children could be nurtured through inquiry-based learning in the classroom (Brandwein, 1995). Keeley (2009) lends further credence by stressing the importance of science in the early grades to maximize the cumulative learning processes involved in developing science talent and argues that if children are not given an early exposure to science instruction, their science achievement and conceptual understanding would subsequently be adversely affected. Meanwhile, Pratt (2007) claims that the curiosity and enthusiasm for science among children may continually diminish if not fostered in the early grades. Such diminution and attenuation of interest in science will lead to students either pursuing another interest apart from science, or losing the desire to take an advanced course in science. While science and mathematics are taught across the kindergarten, primary and secondary curricular, these disciplines are not explicitly taught in the early childhood curriculum. Accordingly, an important research question emerges from this scenario, namely, is it feasible to integrate STEM into the current early childhood curriculum in Malaysia?

Early Childhood Curriculum in Malaysia

The Early Childhood Curriculum in Malaysia is called "*Kurikulum* PERMATA *Negara*" (PERMATA, 2013), which is literally translated as "National GEMSTONE Curriculum". "PERMATA", in the Malay language, means gemstone or diamond. It is named as such because the Malaysian Government believes that "every child is precious" just like a gemstone/diamond which needs to be cut, shaped, and polished to reveal its brilliant final beauty. The "*Kurikulum PERMATA Negara*", meant for the 0-4 year olds, was developed in 2007, trialled and implemented nation-wide in 2008.

A document review shows that there is no explicit documentation of STEM in the Early Childhood Curriculum. However, elements of STEM can be inferred from the conceptual model of its curriculum as shown in Figure 1 which is lifted from PERMATA (2013, p. 34).

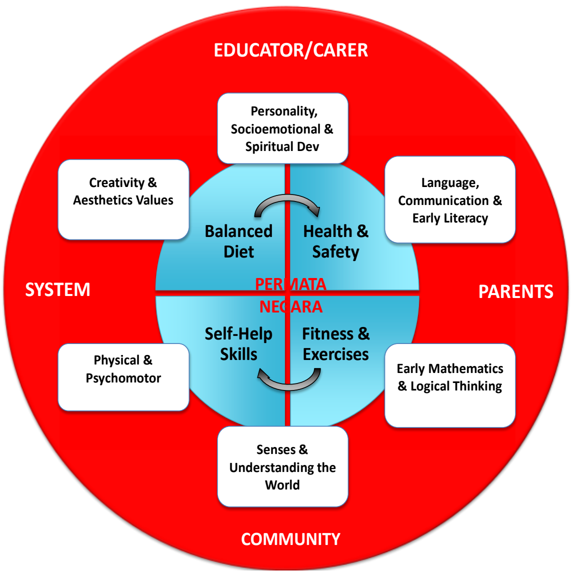

Figure 1. *Conceptual Model for the National Early Childhood Curriculum*

The conceptual model of the Malaysian Early Childhood Curriculum as depicted in Figure 1 shows the amalgamation of the four aspects in the Childcare component with that of the six Learning Areas for the Child Development achievable through the concerted efforts among the "Educator/Carer", "Parents", and the

"Community" within a strong supportive "System" from the authorities. The four aspects of Childcare component are *Balanced Diet*, *Health & Safety*, *Self-Help Skills*, and *Fitness & Exercises*, while the six learning areas of children development consisted of: (1) *Personality, Socio-Emotional & Spiritual Development*; (2) *Language, Communication and Early Literacy*; (3) *Early Mathematics and Logical Thinking*; (4) *Senses and Understanding the World*; (5) *Physical & Psychomotor*; and (6) *Creativity and Aesthetics Values*.

Among the six learning areas on children development, two of which allude to STEM, namely the (a) Early Mathematics and Logical Thinking, and (b) Senses and Understanding the World. The former matches the "Mathematics" part of STEM, while the latter, the "Science" part. However, there is a confusion as to what STEM constitutes as indicated by Bybee (2013) who laments that "there seemed to be a lack of clarity about the meaning of STEM" (p. ix), due to the fact that the "meaning or significance of STEM is not clear and distinct" (p. x). Bybee (2013) raises the question of whether STEM refers to "a school discipline such as science or mathematics? … [or, does it refer to] four separate disciplines: science, technology, engineering, and mathematics? Or [does it refer to an integration of] two, three, or all four STEM disciplines?" (p.1). In the context of early childhood education in this paper, we take the position of STEM as being an integration of four STEM disciplines which will be further elaborated during the discussion on STEM integration through **P**roject-Based **I**nquiry **L**earning (PIL).

Pedagogical Approach in Early Childhood Education

One of the characteristics of children is their inquisitive nature, constantly asking questions about the world around them. This leads to the strong advocacy of inquiry-based science education. The advocated pedagogical approach in the early childhood curriculum in Malaysia is that of "play pedagogy" (PERMATA, 2013, p.34) which entails exploration, experimentation and experiencing (3E). However, this "play pedagogy" is devoid of the explicitly stated opportunity for children to inquire (I), and to collaborate, create and communicate (3C) which have been strongly advocated for by early childhood educators (Katz, 2010; Katz & Chard 2000; Helm & Katz, 2001).

Therefore, the pedagogical approach proposed for this study on STEM integration is that of the **P**roject-Based **I**nquiry **L**earning (PIL) which promotes the "I + 3E + 3C" by means of four interdependent phases, namely Inquiry, Exploration, Experimentation/Creation, and Reflection. Figure 2 illustrates the enhancement or up-scaling of Play-Based Learning (i.e., the PERMATA pedagogy) to that of Project-Based Inquiry Learning (Aminah et al., 2015) which is the STEM pedagogy that we have theorised and proposed.

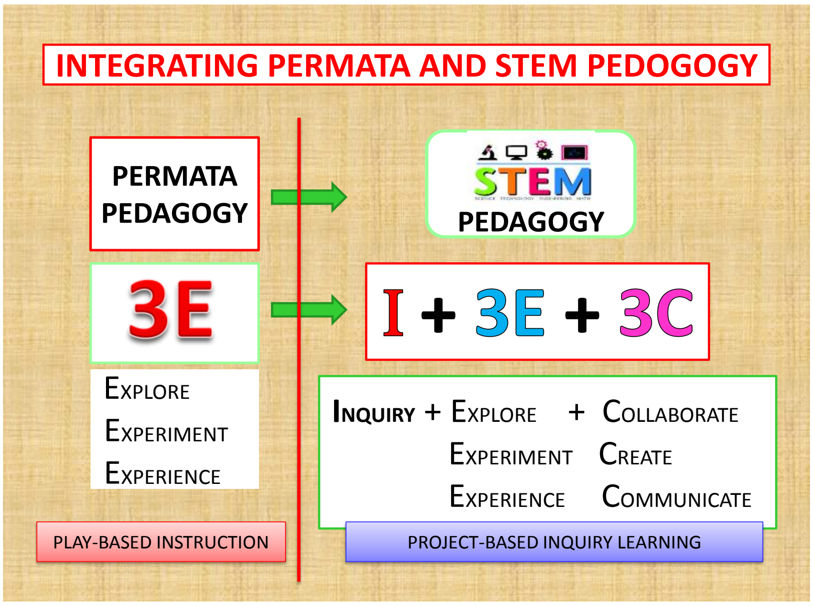

Figure 2. *STEM-Based Teaching and Learning Method*

METHODOLOGY

This study employed a post-intervention and post-implementation survey design in which (i) an intervention in terms of training workshop was given and this was followed by a survey on the suitability of the STEM Projects for 3-4 year-old children from the teachers' perspective, and (ii) the actual classroom implementation was enacted by the participants and this was followed by a survey on the feasibility of the STEM Projects.

Judgmental sampling was used in this study in which the segments of the population represented a variety of early childhood centres in urban and rural parts of Malaysia. In view of the cost constraint, only 22 early childhood teachers from 19 various childcare centres across urban and rural areas of Malaysia were selected as participants.

In the intervention phase, the participants followed through a three-day fully residential in-service training workshop on the integration of STEM through Project-based Inquiry Learning (PIL) held at the Centre for the Gifted and Talented, National University of Malaysia (UKM). In the training workshop, participants were familiarised to the concept of STEM and PIL through PIL itself, in which participants took the dual role of a teacher and that of a child for each project, walking through the 4 phases of PIL under the facilitation of the researchers. Table 1 lists the 10 projects that were presented to the participants during the training workshop. Given that it was only a three-day in-service training workshop and that the time allocated was only sufficient to carry out three full cycle of PIL, each group chose one out of the 10 projects in each round (without any overlapping of projects among the groups) to walk through the full cycle of PIL in a collaborative manner, putting themselves in a dual role of a teacher and that of a child. For example, when they assumed the role of a teacher, they asked themselves "what do we want to know about ....", and when they switched role to that of a child, they explicated their questions with one of the team members listing down the questions posed by other members. At the end of each round (i.e., each full cycle of PIL), the groups presented the teaching and learning which took place in each of the four phases – Inquiry, Exploration, Invention, & Reflection. They then showcased their projects with other groups celebrated together with them.

Table 1. The List of Projects Presented at the Training Workshop

Project No	Title
Project 1:	Rubber-Band Powered Car
Project 2:	3R – Reduce, Reuse & Recycle
Project 3:	Terrarium
Project 4:	Buttons
Project 5:	Tie and Dye
Project 6:	Composting
Project 7:	Umbrella
Project 8:	Chicken and Eggs
Project 9:	My Ship
Project 10:	Paper

In the classroom implementation, participants were supported with resource kits during a five-month duration, after which the teachers reported on the STEM Projects which they have carried out with their 3-4+ year-old children in their respective classrooms.

FINDINGS

Table 2 indicates the perceptions of the workshop participants (early childhood teachers) as to the suitability of the STEM Projects for 3-4+ year-old children in their respective childcare centres. Over 90% of the participants perceived Project 9 (My Ship) as the most suitable STEM project for their 3-4+ year-old children, followed by Project 2 (3R – Reduce, Reuse & Recycle), Project 4 (Buttons), and Project 5 (Tie and Dye) where more than 80% of the participants perceived that these projects are suitable for their 3-4+ year-old children. Project 1 (Rubber Band Powered Car), Project 8 (Chicken and Eggs), and Project 10 (Paper) were averagely perceived (slightly above 70%) by the participants as suitable for their children. Nevertheless, Project 3 (Terrarium), Project 6 (Composting) and Project 7 (Umbrella) were the least perceived (between 45% – 60%) as suitable.

Table 2: **Suitability of STEM Projects for 3-4+ Year Olds**

Project No		N	f	%
Project 9	My Ship	22	20	90.91
Project 2	3R	22	18	81.82
Project 4	Buttons	22	18	81.82
Project 5	Tie and Dye	22	18	81.82
Project 1	Rubber Band Powered Car	22	17	77.27
Project 8	Chicken and Eggs	22	16	72.73
Project 10	Paper	22	16	72.73
Project 3	Terrarium	22	13	59.09
Project 6	Composting	22	11	50.00
Project 7	Umbrella	22	10	45.45

Table 3 summarises the STEM Projects which have been implemented by the early childhood teachers in their respective childcare centres within a 5 month duration. It was found that Project 3 (Terrarium) was the STEM Project which garnered the highest frequency in terms of implementation across the childcare centres. All of the childcare centres, except for one, carried out the Terrarium Project with their 3-4+ year olds. Project 2 (3R) and Project 5 (Tie and Die) were implemented by 63% of the childcare centres. While the remaining STEM Projects were implemented by less than 50% of the childcare centres, Project 7 (Umbrella) and Project 4 (Catapult) were implemented by only two (10.53%) of the 19 childcare centres.

Table 3: The Frequency and Type of STEM Projects Implemented

Project #		frequency (n=19)	%
Project 3	Terrarium	18	94.74
Project 2	3R	12	63.16
Project 5	Tie and Die	12	63.16
Project 9	My Ship	8	42.11
Project 10	Paper	8	42.11
Project 6	Composting	6	31.58
Project 8	Chicken and Eggs	5	26.32
Project 1	Rubber Band Powered Car	4	21.05
Project 7	Umbrella	2	10.53
Project 4	Catapult*	2	10.53

* Project 4 – Catapult replaces Button Project due to the validation process by the participants who felt that it is less within the scope of STEM Education.

CONCLUSION and DISCUSSION

The main finding of this research indicates that it is feasible to integrate STEM into the Early Childhood Curriculum as supported by the survey data of the early childhood teachers collected at two different junctures: (1) at the end of the training workshop where teachers reported on the suitability of the STEM Projects for early childhood pupils aged 3 to 4+, and (2) at the end of the five-month classroom implementation where teachers reported on the STEM Projects which they have carried out with their 3-4+ year-old children.

However, there were some mismatches between the STEM Projects which the teachers perceived as suitable with that of the STEM Projects which were actually implemented in the classroom. For example, while Project 9 (My Ship) was highly perceived as the most suitable STEM Project for 3-4+ year-old children, this project was only implemented in 8 out of 19 (42.11%) childcare centres. By contrast, while Project 3 (Terrarium) was grimly perceived on its suitability as a STEM Project, it was nevertheless the Project which was implemented in 18 out of 19 (94.74%) childcare centres.

Therefore, it would be more illuminating if follow up interview could be done with the teachers so as to uncover the underlying reasoning for the mismatches between what was initially perceived as suitable with that of actual implementation. Although it could be inferred that such mismatches arose out of many reasons, ranging from the suitability in terms of jiving with students' cognitive and ability level, to the curricular demand in terms of jiving with the weekly learning themes for the childcare centres, getting teachers' personal responses seems to be the way forward in getting the valid reasoning.

The feasibility of STEM integration for early childhood education was premised on two existing facts in that the components of science and mathematics are in existence within National PERMATA Curriculum, and that the use of Project-Based Inquiry Learning matches the inquisitive nature of the 3-4+ year-old children to inquire, explore and design, investigate and create/invent, and to talk about their inventions or/and investigations.

Based on these findings, it is suggested that the Permata Division at the Prime Minister's Department relooks at the existing National PERMATA Curriculum and identifies the gaps and opportunity to embed and integrate STEM education into the existing Curriculum. Besides, concerted effort is needed to develop and validate more STEM Projects for the consumption of the early childhood teachers across the various early childcare centres in Malaysia. Should the suggestion be adopted, the Malaysian children will definitely be nurtured with STEM education which eventually leads to more students pursuing science (Pratt, 2007), thus helping the country in realising the 60:40 ratio as echoed in the speech of our Prime Minister given at the United Nations: "Malaysia aims for 60 per cent of its children and young people to take up Science, Technology, Engineering and Mathematics (STEM) education and career for a better future of the country. … There is a need for us to ensure a new generation of children and young people passionate about STEM education so that they want to choose STEM as a career" (Bernama, 23 September 2014).

REFERENCES

Ayob, A., Ong, E.T., Ibrahim, M.N., Adnan, M., Shariff, J., & Isyak, N. (2015). Stem In The Early Childhood Education In Malaysia. Paper Presented At The Early Childhood Care & Education International Rendezvous (Ecceir 2015), The Gardens Hotel, Kuala Lumpur, 4-6 August, 2015.

Azian, T. S. A. (2015). *STEM Education: Policies and prospects towards achieving international standard and meeting national development needs*. Keynote address given at International Science, Technology, Engineering and Mathematics High-Level Policy Forum on Evidenced-Based Science Education in Developing Countries, 26-27 May 2015, Istana Hotel, Kuala Lumpur.

Bernama (2004, September 23). *PM leads Malayisa as a founding nation of the "Global STEM Alliance" at United Nations*. Accessed on September 24, from http://mrem.bernama.com/viewsm.php?idm=23034

Brandwein, P. F. (1995). *Science talent in the young expressed within ecologies of achievement* (RBDM 9510). Storrs, CT: The National Research Center on the Gifted and Talented, University of Connecticut.

Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. Arlington, Virginia: National Science Teachers Association Press.

Helm, J. H., & Katz, L. G. (2001). *Young investigators: The project approach in the early years*. New York: Teachers College Press.

Katz, L. G. (2010). *STEM in early years*. Collected Papers from the SEED (STEM in Early Education and Development) Conference. Retrieved September 30, 2015, from http://ecrp.uiuc.edu/beyond/seed/katz.html

Katz, L. G., & Chard, S. C. (2000). *Engaging children's minds: The project approach* (2nd ed.). Stamford, CT: Ablex.

Keeley, P. (2009). Elementary science education in the K-12 System. *NSTA WebNews Digest*. Retrieved on July 30, 2015 from http://www.nsta.org/publications/news/story.aspx?id=55954

PERMATA. (2013). *Kurikulum Permata Negara: Asuhan dan Didikan Awal Kanak-Kanak 0-4 Tahun*. Cyberjaya: Jabatan Perdana Menteri.

Pratt, H. (2007). *Science education's "overlooked ingredient": Why the path to global competitiveness begins in elementary school*. Retrieved on July 30, 2015, from http://science.nsta.org/nstaexpress/nstaexpress_2007_10_29_pratt.htm

National Science Board (2010). *Preparing the next generation of STEM innovators*: *Identifying and developing our nation's human capital*. Arlington, Virginia: National Science Foundation. Retrieved on July 30, 2015 from http://www.nsf.gov/nsb/publications/2010/nsb1033.pdf