PARENTS' PERSPECTIVES ON ELEMENTARY ENGINEERING EDUCATION USING HANDS-ON, HEADS-ON, AND HEARTS-ON (3HS) APPROACH

Lee Yee Ling
Department of Curriculum and Instructional Technology,
Faculty of Education, University of Malaya

Nur Azah Hamzaid
Department of Biomedical Engineering,
Faculty of Engineering, University of Malaya
azah.hamzaid@um.edu.my

ABSTRACT

The concept of hands-on, heads-on, and hearts-on (3Hs) education, which conceptualises "whole-child" development in terms of a child's cognitive, social, physical, and affective domain can be appropriately integrated into elementary engineering education. This study aimed to assess parents' perceptions on a 3Hs elementary engineering education program, *Let's Go to Mummie's Lab*, which they participated as co-facilitators. Using survey questionnaires and interviews, the parents' opinions on this 3Hs program were collected and analysed. The study found that the parents gave positive responses to this 3Hs program from the aspects of training session, teaching materials as well as the benefits of this program to the parents themselves and the young students. The parents suggested that making the activities more diverse and prolonging the duration of this program could ensure its sustainability. Training session for parents and physical environment also needed to be improved. This study suggests that 3Hs elementary engineering education can be promoted through activity-based, constructivist education environment, interest-based learning, and play. This research encourages schools to involve parents in promoting 3Hs elementary engineering education for the benefits of stakeholders, including parents and young children.

Keywords: hands-on, heads-on and hearts-on (3Hs) education, elementary engineering, *parents' perspectives*

INTRODUCTION

Infusion of engineering education into elementary school curricula can enhance students' knowledge, skills, and positive attitudes towards science learning (Mann, Mann, Strutz, Duncan, & Yoon, 2011). This initiative can prepare students for future work force in the field of science, technology, engineering, and mathematics (STEM) (English & King, 2015; Mann et al., 2011; Marulcu, 2014). Engineering themes, content, practices, and values have been integrated into primary and secondary school curricula to bolster student engagement in engineering education (English & King, 2015). Despite the concerted efforts to introduce engineering education to young students, engineering education is still underrepresented in elementary school curricula (Marulcu, 2014). The "E" in STEM has always been neglected by educators (Marulcu, 2014). As a result, children have insufficient engineering knowledge and hold alternative conceptions of engineering learning (Lachapelle & Cunningham, 2014). For example, they use the term "engineering" to refer to the practices of technology designs (Lachapelle & Cunningham, 2014). Students develop their own understanding and theories to explain their surrounding world based on their interpretations on their daily experiences and observations (Marulcu, 2014).

To address these challenges, introducing engineering education to elementary school students is timely and appropriate. In Malaysia, national policy reports call for an increased exposure to engineering knowledge starting with the elementary grades through Design and Technology subject (Curriculum Developement Centre, 2015). The aim of elementary engineering education is to "open children's minds to the diversity and ubiquity of technology and engineering, and to encourage the attitudes and habits of mind that will lead to their becoming agents of change for, not just consumers of, their developing world" (Lachapelle & Cunningham, 2014, p. 61). Engineering education is built on young children's natural inclination to tinker, design, create, and their curiosity to explore how a device functions (Lachapelle & Cunningham, 2014; Mann et al., 2011). Children always attempt to construct dissembled home household device (Mann et al., 2011). Engineering education allows young children to engage joyfully in hands-on and idea-stimulating activities when they design and construct artefacts which are relevant to their needs in daily life (Inan, 2007; Inan & Inan, 2015; Park, 2010). Besides, engineering activities integrate well with science, mathematics, and technology knowledge (Marulcu, 2014).

The concept of hands-on, heads-on and hearts-on (3Hs) education, which embodies "whole-child" development can be integrated into elementary education to promote engineering education at an early age. 3Hs education encompasses a child's cognitive (e.g. reasoning and predicting), social (e.g. interactions and collaboration with social members), physical (e.g. use of motor and kinaesthetic skill), language (e.g. engaging in verbal and non-verbal communications) and affective skills (e.g. interest and emotional activities) (Inan, 2007; Inan & Inan, 2015). Research has documented that children who engaged in 3Hs education gained an interest in science-related activities and science processes as well as become more acquisitive about science issues (Inan & Inan, 2015).

Apart from the children themselves, parents play a crucial role in facilitating young children learning in STEM education (Chung & Santos, 2018; Koehler, Park, & Kaplan, 1999; Lee, 2012; Rozek, Svoboda, Harackiewicz, Hulleman, & Hyde, 2017). Parent involvement in STEM outreach programs can enhance children's knowledge, trigger their interest in learning, and strengthening family bond (Koehler et al., 1999; Lee, 2012). Parents can also form partnership with school teachers and other academic professionals during out-of-school learning programs to collaboratively support children learning (Lee, 2012). Studies have shown that when parents and children were put together in informal STEM learning programs such as a robotics carnival where the parents were trained as challenging learning station managers, they had the opportunity to solve engineering problems together (Chung & Santos, 2018). The parents showed increased confidence in engineering education, and thus, they could inspire and motivate their children to engage in STEM learning (Chung & Santos, 2018). Rozek et al. (2017) found that that parents could increase their children's STEM preparation and career pursuits by communicating the utility values of STEM subjects to their children.

Since parents have great influence on children's learning, manipulation of existing learning programs for effective STEM learning should be centred around them (Rozek et al., 2017). Curriculum developers, however, seldom involve parents in designing a learning program for young children. Besides, research on parent involvement and their perceptions on 3Hs engineering education program is still extremely limited. Existing research merely focus on investigating teachers' roles (Inan & Inan, 2015) and their perceptions (Park, 2010) on 3Hs education. This research study attempted to fill these gaps by investigating parents' perceptions on a 3Hs elementary engineering educational program, which they acted as co-facilitators.

Pestalozzi's Hands-on, Heads-on and Hearts-on (3Hs) Learning Approach

This study reports findings from a larger research that focused on inclusion of 3Hs engineering education into Year 1 elementary classrooms through a program named *Let's Go to Mummie's Lab*. The 3Hs approach is coherent with Pestalozzi's philosophy of education which advocates the development of a wholesome person (Horlacher, 2011). Pestalozzi's approach highlights the importance of achieving a balance between hands, heart and head (Pestalozzi, 1984). A child who engages in Pestalozzi's learning approach can develop the characteristics of an active and intellectual learner, as well as cultivate moral values and social skills (Horlacher, 2011; Inan & Inan, 2015). Inan and Inan (2015) further elaborated that a child's holistic thinking is gained from doing, thinking and feeling.

Pestalozzi advocated that there is a close relationship between home and formal learning to promote a child's holistic development (Bowers & Gehring, 2004). Close mother-child relationship ensures a child's successful social development (Bowers & Gehring, 2004; Ito, 2016). Discourse of love, care from parents, especially mothers' characteristics have great impacts on their children's early learning stage (Ito, 2016). *Let's Go to Mummie's Lab* program attempted to empower parents as co-facilitators for their children's 3Hs engineering learning in school, and potentially, to apply the experiences and knowledge gained from this program to out-of-school learning. This program was developed with the expectation that parents could guide their children's engineering learning at home after they participated this program. This program also provided students with simplified, yet practical learning experiences equivalent to that of the on-campus biomedical engineering students through activity-based and play-based activities.

In this research, the participating parents were informed by the school administrators about this program. The parents joined this program voluntarily as facilitators. One week before the implementation of this program, the parents were given a training session which lasted for two hours. During the training sessions, the program coordinators, who were the senior lecturers from a local university and the research assistants, explained the flow of the activities to the parents. In line with the Pestalozzi's approach which advocates the use of tangible objects to help students make sense of knowledge (Bowers & Gehring, 2004), the program coordinators demonstrated the construction of teaching aids, including the models of hand straws, prosthetic leg models, and edible cells. The parents were given the opportunities to help the program coordinators prepare the teaching aids for the students.

Methodology

Samples

The current study involved 27 parents from four national primary schools in Malaysia. One school is situated in the rural area at the southern part of Malaysia. The sub-urban school is situated at the out-skirt of Kuala Lumpur, the capital of Malaysia. The remaining two schools are situated in Kuala Lumpur. Among the four schools, two were all-girl schools. The remaining schools were co-education schools. The questionnaire was distributed to all participating parents but only twenty-three questionnaires were returned. The background information of the respondents is shown in Table 1.

Table 1
Research Location and Respondent's Demographic Information

School	Location	Types	Number of Parents		Total
			Father	Mother	
School A	Rural area, Johor	Co-education		6	6
School B	Sub-urban, Selangor	All-girls		6	6
School C	Urban, Kuala Lumpur	Co-education	1	5	6
School D	Urban, Kuala Lumpur	All-girls		5	5
Total			1	22	23

Data Collection

The parents' perceptions on the 3Hs program were collected from survey questionnaires and parent interviews. The questionnaires were distributed to the parents at the end of the program. They were given 30 minutes to complete the questionnaires. Eight parents were randomly interviewed to gain an in-depth view on this program after they filled in the questionnaires.

Instrument

A combination of open-ended and closed-ended questions was used in the present study to assess the parents' perceptions on this 3Hs program. The six aspects assessed in the questionnaire were:

(a) Question 1: Activities of the *Let's Go to Mummie's Lab*;
(b) Question 2: Teaching aids for children;
(c) Question 3: Benefits of *Let's Go to Mummie's Lab* to children;
(d) Question 4: Parents' training session;
(e) Question 5: Benefits of *Let's Go to Mummie's Lab* to parents; and
(f) Question 6: Suggestions for promoting 3Hs elementary engineering education

The questionnaire comprised of three closed-ended questions (Question 1 to Question 3) and three open-ended questions (Question 4 to Question 6). Each item in the closed-ended questionnaire was given a code to be used in the process of data analysis. Each question contained different number of items. A four-point Likert-scale with the response categories 'strongly agree', 'agree', 'disagree', and 'strongly disagree' was used in the first three questions. The response scores for 'strongly agree' was assigned a point value of 4, 'agree' had a point value of 3, 'disagree' had a point value of 2, and 'strongly disagree' was assigned a point value of 1.

On the other hand, the open-ended Question 4 to Question 6 encouraged the parents to provide full, meaningful answers about the training session, benefits of this 3Hs program to parents and recommendations for improving this program using their own knowledge. Two senior lecturers from a local university checked and verified the questionnaire to ensure content validity. The questionnaire was pilot-tested with five parents whose child joined *Let's Go to Mummie's Lab program* during school holiday. The pilot test aimed to ensure that the questions were appropriate and could provide useful data to answer the research questions.

Parent interviews

Semi-structured interview which combines a pre-determined set of less and more structured questions provides opportunity for a researcher to further explore particular themes (Merriam, 2009a). The interview questions focused on gaining a deeper understanding of the parents' perceptions on the six aspects of the 3Hs elementary engineering education assessed in the questionnaire. Generally, these questions are related to their opinions on the program structure, appropriateness of teaching aids and activities, as well as the ways to improve this program. The researcher asked questions according to the situation as well as identified emerging themes and new ideas during the interviews (Merriam, 2009a). Each interview which lasted for about 15 minutes was video-recorded.

Data Analysis

The mean score for Question 1 to 3 were computed using SPSS 17.0 packages. The participants' responses to Questions 4 to 6 were broken into discrete parts and coded. The codes were compared and collapsed into category till a point of saturation where no new category emerged (Creswell, 2008). A table of description was developed to represent the results. Frequency distributions (*f*) and percentages (%) were computed to determine the number of parents sharing the same ideas. For the survey questionnaire, the parents' responses were numbered from S1 to S27. The responses to the survey questionnaire were complemented with excerptions obtained from the parent interviews. The excerptions were used as examples and empirical supports for the items in the questionnaire.

The parent interviews were transcribed verbatim. The interview transcriptions were broken into discrete parts and coded. The overlap and redundant codes were then reduced, followed by categorising these reduced codes into themes (Merriam, 2009b). Existing themes were either added on or further collapsed into more refined themes till the categories were saturated (Merriam, 2009b). The parents' responses were numbered from P1 to P8. As the parents answered the survey anonymously, their identity could not be identified. It meant that respondent S1 and P1 might not be the same person.

Results

The research findings about the parents' perceptions on 3Hs elementary engineering education program are presented in the following session.

Question 1: What are your perceptions about this *3Hs elementary engineering education program—Let's Go to Mummie's Lab*?

The parents' perceptions about the activities of the 3Hs elementary engineering education program are shown in Table 2.

Table 2
Mean Score for Activities of 3Hs Elementary Engineering Education

Item	Activities in this project	Mean score
101	Well-planned	3.45
102	Utilizes various techniques such as "learning through play"	3.58
103	Suitable with the students' mastery level	3.53
104	Fulfils the objectives of the project	3.47
105	Involves a lot of hands-on activities	3.47
106	Creative and innovative	3.74
107	Sufficient time to complete the activities	3.37

All the items in Question 1 were rated more than 3.0, meaning that the parents agreed that the activities of this program satisfied all the criteria listed. Item 102, 103 and 106 scored more than 3.5. Item 102 obtained the highest mean score of 3.58. This showed that the activities allowed the children to explore the field of science and technology through activities and play. It was plausible that the *Mummie's Lab* team brought a lot of science and technology materials such as real artefacts of bionic hand and prosthetic leg to school. Two parents explained,

> *The kids liked the activities such as constructing prosthetic leg and edible cells. They involved in various hands-on activities. They also enjoyed the ice-cream and soap making activities. They were very excited. (P2)*

> *The activities allowed the students to learn while they were playing. The activities were more interesting and fun compared with formal class lessons. (P5)*

Item 101, 104, and 105 recorded a mean score between 3.40 to 3.49. The parents agreed that the sequence of the activities was smooth and suitable with the students' mastery level. They explained:

> *The sequence of the activities was well-planned. All activities started with an introduction such as singing and dancing. It was followed by explanations and construction of models. (P3)*

> *I think the children could follow the activities well. The facilitators explained the activities in simple sentences. (P8)*

Item 107 indicated that time constraint was a weakness of this program. This situation might be caused by the dynamic and fluid learning context in a school. As explained by the parents, factors such as students' abilities and their engagement in the activities affected the time taken to complete the tasks:

> *The time was too brief. The students completed some activities such as making hand straws in a rush. (P3)*

> *The students have different abilities. Some students completed their tasks faster than the others. Some students are more playful. We spent more time to keep them on track. (P8)*

Question 2: What is your opinion about the teaching aids used in this program?

Various visual and audio concrete teaching aids such as hand straws, soaps and model of prosthetic leg were used in this program to promote student's 3Hs learning. The distribution of the parents' opinions on the teaching aids used in the 3Hs elementary engineering education program is shown in Table 3.

Table 3
Mean Score for Teaching Aids

	Teaching aids	Mean score
201	Explains science concepts well	3.32
202	Helps students to stay focused on the activities	3.58
203	Creative and innovative	3.58
204	Economic and cost-saving	3.47
205	Suitable with students' intellectual developmental level	3.63
206	Enhance students' interest in STEM	3.47

The mean score of all items was 3.51 over 4. Item 206, which was related to the use of teaching aids to promote students' intellectual development level scored the highest (mean score = 3.63). The parents also agreed that the teaching aids attracted the students' attention and helped them stay focused throughout the implementation of the program (Item 202). The mean score for this item was 3.58. Two parents stated that:

> *The students enjoyed playing with the stitched models. They took the parts down and put them back. They were attracted by the models and learned the name of each digestive organ when they played with the models. (P4)*

> *The teaching aids were interesting. The young kids listened attentively to the explanations given by the facilitators. (P5)*

Item 203 was rated 3.58, meaning that the parents thought that the teaching aids used were creative and innovative. The mean score for Item 204 and 206 ranged between 3.40 to 3.47. The parents agreed that the teaching aids were economic (Item 204) because simple and environmentally friendly materials such as recycled mineral water bottle and broom stick were used to build the model of prosthetic leg:

> *Now I know that some simple stuffs available at home such as straws and wood could be used as teaching materials. This reduces the cost of a teaching aid. (P6)*

The parents rated the teaching aids in term of their effectiveness in explaining science concepts (Item 201) lower than other items. The parents held contradicted opinions in terms of the educational purposes of the teaching aids:

> *The children could understand how a hand moves and the function of a prosthetic leg through construction models. (P7)*

The children were more interested in constructing models than telling the science knowledge. They were not very good in explaining the working of the hands. (P1)

Question 3: What are the benefits of this program to the Year 1 students?

Table 4 shows the benefits of the 3Hs elementary engineering education program to the young students from the parents' perspectives.

Table 4
Mean Score for Benefits of 3Hs Elementary Engineering Education to Year 1 Students

	Benefits of 3Hs Elementary Engineering Education	Mean scores
301	Enhances students' interest to learn science, technology and engineering	3.58
302	Encourages cooperation and collaboration among the students	3.63
303	Enhances students' knowledge in science, technology and engineering	3.55
304	Provides enjoyment and learning opportunity simultaneously	3.63
305	Improves higher order thinking skills	3.63
306	Encourages students to explore the world of science, technology and engineering independently	3.97
307	Strengthens relationship between parents, teachers and students	3.68
308	Gives opportunity for students to use high-tech devices	3.61
309	Improves students' creativity	3.57

All items in Question 3 were rated more than 3.50. The mean score for Item 406 was the highest (mean score = 3.97). The parents strongly agreed that this program encouraged their children to explore the world of science, technology, and engineering independently (Item 306). For example, two parents explained,

My daughter already has some knowledge about human body and skeleton. This program reinforces her knowledge. It is an extension part of the theories. I think its level is higher than what is being taught in school. (P6)

My daughter asked for straws and strings when she reached home. She was eager to construct the hand models herself. (P7)

Item 302, 304, 305, 307, and 308 recorded a mean score between 3.60 to 3.69. The parents agreed that this program was beneficial for students in term of promoting higher order thinking skills (Item 305) as well as collaboration and cooperation (Item 302 and 307). This program also provided enjoyable learning experiences (Item 304) and giving chances for the students to use sophisticated technology (Item 308). A parent said:

This program is an eye opener for the children. My child has never seen a bionic arm and prosthetic leg in real-life. Now, she had the opportunities to see, touch and use these devices in the school. (P2)

From the aspect of cooperative learning, the children helped each other when they were constructing a prosthetic leg in groups. A parent expressed her view that:

The children worked in groups and they had lots of fun learning together. Some of them comes from different classes. They had the chances to mix and worked with peers from other classes. (P1)

The mean score of Item 303 was 3.55. The parents agreed that this program enhanced their children's knowledge in science and technology. For example, two parents explained:

> *Collaboration between university and schools is very meaningful. The lecturers and university students brought their knowledge and skills from the university to elementary schools. My child gained basic biomedical knowledge. (P2)*

> *This program gives awareness to young children that knowledge in science and technology is important in daily life. They also know that technology develops and changes every day. (P5)*

The parents also agreed that this program enhanced their children's interest in science, engineering and technology subjects (Item 401, mean score 3.58). As explained by P1,

> *Kids may want to pursue this particular field (biomedical engineering) in the future and they know what can be done to fulfil their ambition. It is a good thing that they know such thing (biomedical engineering) exists. When I was young, I was not aware about this. (P1)*

The mean score in terms of creativity was 3.57. P6 explained,

> *The activity which promotes the students' creativity like designing and drawing the bionic hands, is suitable for young children. (P6)*

Question 4: What is your opinion about the training for parents?

The parents gave a wide range of opinions on the impacts of training on them. Three categories emerged from the data: (a) interaction, (b) knowledge enhancement, and (c) self-preparedness. The themes and sub-themes and their respective frequency are shown in Table 5.

Table 5
Parents' Opinions on Training Session for Parents

Themes	Sub-themes	Responses	
		f	%
Interaction	Parent-organizer	1	33.3
	Parent-parent	2	66.7
Knowledge enhancement	Content specific	12	60.0
	Pedagogical content	8	40.0
Self-preparedness	Mentally-prepared	2	28.6
	Experiential experiences	5	71.4

The research found that most of the parents (n=20) shared the same opinions that the training for them enhanced both their content specific knowledge and pedagogical content knowledge. Two examples of the responses were:

> *I gain information about the bones, internal organs, and digestive system. I learned these concepts during my secondary school years but I can hardly recall the scientific terms now. Through this program, I learned those terms again. (S16)*

> *Since I stay in a village, I am less exposed to computer. Now, I know more about science and technology. I played computer game related to bones and learned the English name of the organs during the training session and the actual program. (S18)*

I know more about the ways to get children interested in science activities, such as doing more hands-on activities…like making soap and constructing cell models using food. (S22)

Seven parents expressed the views that the training session prepared them for the actual program. Some of their responses are:

I could better prepare myself. I knew what to do on the actual day…and how the program would be conducted…and also how we might help young students in the village improve their knowledge about science and technology. (S15)

I felt more secured if I knew the activities in advance. I am more confident to facilitate the kids. (S21)

Three parents mentioned that this program strengthened the relationship between the participants. For example, they wrote that:

This training session strengthened the relationship between parents and the program organizer. We had more time to interact during the training session than during the actual program. (S17)

I know other parents better. We seldom communicate in school. We spent more time together when we involved in this program. We discussed about our children's' studies. (S22)

Question 5: What are the benefits you gained from joining this program?

The parents' views on the benefits of joining the 3Hs elementary engineering education program are presented in Table 6. They explained that this program improved their knowledge, strengthened the relationship among the participants and increased their positive emotions.

Table 6
Benefits Parents Gained from 3Hs Elementary Engineering Education

Themes	Sub-themes	Responses	
		f	%
Knowledge enhancement	Content specific	10	58.8
	Pedagogical content	7	41.2
Interaction	Parent-teacher	1	20.0
	Parent-student	3	60.0
	Parent-organizer	1	20.0
Affective domain	Patience	1	50.0
	Enjoyment	1	50.0

Most of the parents (n=17) agreed that they gained both content specific and pedagogical knowledge from their participation in this program. From the perspectives of content specific knowledge, some examples of their responses were:

Now I know how to make ice-cream and soap. I can do these activities with my child at home. (S5)

This program is very good. I gained new knowledge which I do not know before like prosthetic leg and bionic hand. (S8)

From the aspect of pedagogical content knowledge, the parents responded:

I know that teaching and learning process can happen through play. (S7)

This program gives me the ideas and experiences to teach my kids at home. (S12)

I knew how to teach my kids science and technology knowledge in simple and effective way using the resources available at home. I also learned more about play-based learning. (P8)

Five parents responded that this program was beneficial in terms of improving interactions between all parties. Some examples of the responses from the questionnaire were:

I think the parents are now closer with the students and teachers. We have more chances to interact during the activities. (S6)

We, parents could mix and learn together with our kids and the adolescents [the facilitators]. It is good to get involved in our children's' learning program. (S16)

From the perspective of affective domain, P2 expressed that this program taught her to be patient with the young children.

This program gave me enjoyment. I enjoyed learning and doing works with the kids. (P2)

Question 6: What are the aspects that need to be improved to better promote 3Hs elementary engineering education among young students?

Even though parents gave good comments for this program, they also shared their opinions on how this program could be improved from a few aspects namely: (a) nature of program, (b) training for parents, and (c) physical environment. The parent's suggestions are shown in Table 7.

Table 7
Suggestions for Improving 3Hs Elementary Engineering Education

Themes	Sub-themes	Responses	
		f	%
Nature of program	Diversity of Activity	6	33.3
	Duration	6	33.3
	Sustainability	5	27.8
	Topic coverage	1	5.6
Facilitators	Characteristics	1	100.0
Training for parent	Preparation	2	100.0
Physical environment	Venue	3	100.0

The parents (n=6) who thought that the 3Hs activities needed to be improved from the aspect of diversity wrote that:

More experiments can be added. The kids need practical activities rather than theory. (S3)

Some activities and the procedures need to be explained in a more detailed and clearer way. (S4)

Maybe the kids need more games...to be more active and engaged. (S14)

These ideas were supported by other parents during the interviews. For example, P5 and P8 mentioned that:

> *This program can include more activities that promote students' creativity. These activities must be compatible with the students' ability too. (P5)*

> *Young children love to perform. They can be asked to explain their ideas and what they have learned from the activities. (P8)*

Three parents showed their concern about the duration of the program. For example, one of them responded that:

> *One session that lasts for three hours is too short. It is very challenging for young kids to understand all concepts and master all skills in such a short time. (S10)*

Five parents expressed their opinions that long-term programs could more effectively promote 3Hs elementary engineering education compared to an ad-hoc program like *Let's Go to Mummie's Lab*. They expressed the thought that well-sustained program would have greater impacts on children's learning. Their responses included:

> *This program needs to be conducted more frequent. It is better to involve students from Year 1 to Year 6 so that more students will be exposed to engineering knowledge. (S13)*

> *The effect of one-day program might be short-term. It's better to organise this program at least twice in a year. (S20).*

Besides, a parent thought that the organiser of *Let's Go to Mummies' Lab* could introduce the notion of 3Hs education to young children in other schools:

> *My daughter said, "I got a name tag with the name 'engineer'!" and my son was like "why we don't have such program in my in my school" and he was so jealous. It is good to have such program in other schools as well. (P4)*

One parent thought that more science-related knowledge could be covered in this program:

> *This program is good but it can be broadened to cover other fields such as astronomy, food technology as well as different areas of engineering such as civil engineering and computer programming. (S12)*

Only a parent commented about the facilitators' attitudes:

> *The facilitators could be more cheerful so that they can be more approachable and develop better relationship with us. (S4)*

Two parents talked about improving the training sessions for parents:

> *The training session can be conducted earlier. If we (parents) need to prepare anything for the activities, we should be informed during the training. (S6)*

> *A one-hour training for parent is too short. We may not grasp the main ideas of all activities. (S8)*

Three parents expressed their views on the suitability of the venue. They expected more spacious activity venue:

> *The venue is quite congested. The kids need more spacious place to move around. (S7)*

It will be better if the activities are conducted in school hall than a classroom. The children hardly had any space to move around. (P1)

DISCUSSIONS

This study reported the parents' perceptions on the 3Hs elementary engineering education program, *Let's Go to Mummie's Lab*, in which they were the co-facilitators. The participating parents highly supported the efforts to promote engineering education through activity-based and play-based learning. This type of program encouraged young students to construct knowledge actively (Liu, Yuen, & Rao, 2015). As suggested by Inan and Inan (2015), 3Hs education connects formal learning in school with the world of science and technology, enhances young children's knowledge and skills as well as promotes their active engagement in learning. The findings were in line with the previous research which showed that play-based activities created a constructive context for children to explore sciences through handling various materials and learning at their own interest (Inan & Inan, 2015). Play-based activities also produce exciting effects, which can cultivate students' joyful attitudes towards learning (Bergen, 2009).

The research revealed that the use of appropriately developed teaching aids contributed to the promotion of 3Hs engineering education among the young students. Teaching materials which are suitable with the elementary students' cognitive development stages help them focus on their task at hand (Bagiati, 2011). Children can construct their engineering knowledge through handling concrete objects (Lachapelle & Cunningham, 2014; Martin, 2000). Besides, materials which are easily obtained from the surroundings encourage parents to teach engineering concepts to children during out-of-school time. However, some parents expressed their concerns about the full affordances of the teaching aids. They thought that their children spent a lot of time on building and playing with the artefacts. Their concern was not baseless as previous studies have shown students paid more attention on building their artefacts rather than understanding the scientific concepts underlying their artefacts (Hmelo, Holton, & Kolodner, 2000).

The parents also agreed that the students were exposed to more sophisticated engineering knowledge about bionic hands and prosthetic legs through their engagement in this program. Using stories which illustrate real-life problems facing fictional characters can teach young children's engineering concepts (Bush et al., 2006). Curriculum which is supported by both teachers and other stakeholders, including parents, can support students engineering learning at young ages (Bagiati, 2011). Besides, the parents agreed that their children benefited from this 3Hs engineering education program. The young students gained experiences in constructing artefacts, designing bionics hands, solving real-life problems, and articulating their scientific ideas. In Inan and Inan's (2015) words, the kids engaged kinaesthetically, cognitively, and emotionally in learning.

Involving parents in school activities brings a lot of benefits to school, parents, and students (Chung & Santos, 2018; Koehler et al., 1999; Lee, 2012). The research findings showed that this 3Hs program had been rewarding to the parents. The training session equipped the parents with knowledge and mental-preparedness for the actual implementation of the program. They were exposed to different teaching strategies to educate young children during the program. These findings were consistent with the previous research which reported that the parents learned scientific knowledge through doing hands-on activities with their kids during the outreach programs (Chung & Santos, 2018; Koehler et al., 1999). Besides, this program provided them with the opportunities to collaborate with other parents, students, and lecturers from the organising university to promote 3Hs education in schools (Bruce, Bruce, Conrad, & Huang, 1997). This program also enabled the parents and the young students to work as a team and acquire new scientific knowledge together (Chung & Santos, 2018; Koehler et al., 1999).

This study builds on the parent involvement literature, adding research-based evidences for the benefits of parent involvement in 3Hs elementary engineering education program. An interesting finding from this study was that the parents could give various constructive suggestions to improve this 3Hs elementary engineering education program in the future. The parents thought that this program could be improved in terms of the aspects of activities and topic coverage, physical environment, facilitator's characteristic, and parents' training session. For example, the parents suggested that a properly-planned training session (e.g., longer training session and early preparation) could help them play their role better. Parents' feedbacks are highly valuable as stakeholders including teachers, parents, school administrators, and curriculum developers significantly influence the implementation of engineering curriculum in early school years (Bagiati, 2011; Chung & Santos, 2018). Collaboration from all parties can help students develop informed engineering knowledge, sophisticated skills and interest in engineering education at an early age.

CONCLUSION

Parents has been identified as 'underutilized resource' in the process of STEM learning. The success of science education in classroom and out-of-school settings is largely influenced by parents' behaviours and their STEM-related values (Šimunović, Ercegovac, & Burušić, 2018). Their involvement influenced children's efficacy and academic achievement in school (Hoover-Dempsey & Sandler, 1995). This research suggests that parents can be trained to become facilitators for school programs. They can contribute significantly to their children's learning through providing professional knowledge, time, and energy (Hoover-Dempsey & Sandler, 1995). Parents can support student learning through modelling, reinforcement and instructional strategies they practice during school programs (Chung & Santos, 2018; Hoover-Dempsey & Sandler, 1995). Besides direct involvement in children's learning, parents' perceptions on learning programs are valuable for evaluation and reflection. They can also provide constructive suggestions to improve the implementation of a particular program they participate based on their lived experiences. Their opinions can help program coordinators and curriculum designers reflect on the design and implementation of a program from the aspects of program structure, appropriateness of teaching aids, and suitability of learning activities.

Future research can investigate how parental involvement in 3Hs elementary engineering education influence student learning from teachers' and students' perspectives. Longitudinal studies which explore the impacts of 3Hs elementary engineering education on student STEM learning when they proceed to higher educational level can also be conducted. Such research can help program designers better understand the long-term effects of 3Hs elementary engineering education on young students' cognitive, physical, and affective development. Future studies can also document parents' lived experiences when they engage in STEM programs using a hermeneutic phenomenological method. Such research can advance understanding on the way to develop and maximise the parents' potential as co-facilitators in STEM-related activities.

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