Jurnal Pendidikan Usia Dini
http://journal.unj.ac.id/unj/index.php/jpud
Volume 13 Edisi 2 November 2019

How to use Loose-Parts in STEAM? Early Childhood Educators Focus Group discussion in Indonesia

Maria Melita Rahardjo[1]
Universitas Kristen Satya Wacana, Indonesia

DOI: https://doi.org/10.21009/JPUD.132.08
Accepted: August 15th2019.Approved: September 4th2019. Published: 30th November 2019

In recent years, STEAM (Science, Technology, Engineering, Art, and Mathematics) has received wide attention. STEAM complements early childhood learning needs in honing 2nd century skills. This study aims to introduce a loose section in early childhood learning to pre-service teachers and then to explore their perceptions of how to use loose parts in supporting STEAM. The study design uses qualitative phenomenological methods. FGDs (Focus Group Discussions) are used as data collection instruments. The findings point to two main themes that emerged from the discussion: a loose section that supports freedom of creation and problem solving. Freedom clearly supports science, mathematics and arts education while problem solving significantly supports engineering and technology education.

Keywords: Early Childhood Educators, Loose-part, STEAM

e-ISSN (Online Media): 2503-0566
P-ISSN (Print Media): 1693-1602

[1] Corresponding Author:
Maria Melita Rahardjo
Email: *maria.rahardjo@uksw.edu*

1 INTRODUCTION

In recent years, STEM (Science, Technology, Engineering, Mathematics) has received extensive attention all around the world (Dejarnette, 2018; C. D. Tippett & Milford, 2017). However, research related to science education in early childhood is still limited (Moomaw, 2012), whereas science education is closely related to STEM. Science education and STEM are often neglected before elementary school. Similarly, research on STEM in Indonesia, especially in early childhood setting, is very sparse even though STEM has become a popular object of discussions.

Previous studies reported that STEM is highly beneficial for the students. Furthermore, different from the common belief that STEM is too challenging for young learners, previous studies indicate that STEM is a valuable element for early childhood education (Clements & Sarama, 2016; Moomaw, 2016; Moomaw & Davis, 2010; C. Tippett & Milford, 2017). Early childhood education, STEM is commonly integrated with arts (Dejarnette, 2018; Sharapan, 2012) and thus it is called STEAM (science, technology, engineering, arts, and mathematics).

The misconception that STEAM requires expensive materials might derive from the belief about science and technology. People tend to link technology with electronic equipment. Several researches aimed to seed students' conception about technology resulted in similar findings. Students commonly associate technology with artefacts, especially modern electronic equipment (DiGironimo, 2011; Lachapelle, Cunningham, & Oh, 2019; Rocha Fernandes, Rodrigues, & Ferreira, 2018). Moreover, people also often associate science with laboratory activities. Research investigating students conception about science found that laboratory activities and tools are often used to symbolize science and scientist (Rocha Fernandes et al., 2018).

Despite of the common misconceptions, science and technology are closely related to children's daily life. We may find children building towers from blocks or observing when the towers collapse. These are science and engineering. STEAM education does not always require sophisticated materials. Things such as blocks, twigs, stones, seeds, paper rolls, milk cartoons, buttons, and other every day materials are perfect for the STEAM learning (Casey et al., 2016). Those everyday materials which can be found almost in any environment are potentially supporting STEAM learning if the children are allowed to play and explore them. Those kinds of materials are called "loose-parts". Loose-parts spark exploration, inventiveness and creativity. (Nicholson, 1972). Based on that statement, we can conclude that loose parts can potentially support STEAM education as they support invention and creativity. Both invention and creativity are closely linked to science, engineering, technology, and arts.

Currently, there are not many studies that investigate loose-parts, STEAM, or the relationship between loose-parts and STEAM, especially in early childhood education settings in Indonesia. There is only one research conducted to investigate STEAM learning in early childhood setting (Munawar, Roshayanti, & Sugiyanti, 2019) which can be found in google scholar. There is a big gap between the practices and the research in the field of loose-parts and STEAM in Indonesia. Therefore, this study addresses the gap by exploring the use of loose parts in children's learning, specifically in relation to the STEAM learning. The research question for this study is "how the use of loose-parts supports science, technology, engineering, arts, and mathematics in children's learning?"

Based on the research questions, the variable that will be investigate in the research are loose-parts and STEAM. STEAM is an abbreviation from "Science, Technology, Engineering, Arts, and Mathematics”. Each of them has their own construct and concept. Loose-parts is the independent variable, which might affect science, technology, engineering, arts, and mathematics happening in children’s learning. Therefore, science learning, technology learning, engineering learning, arts learning, and mathematics learning are the dependent variables in this study. This study will investigate how the use of loose-parts might affect those five areas of learning and in what way loose-parts supports those five areas of learning.

2 THEOTRITICAL STUDY

2.1 *Loose Parts*

Loose parts are materials that can be moved throughout the room and used in an endless way. The use of loose part materials gives children the opportunity to make endless ways to make creations. Loose parts can improve problem-solving skills, creativity, concentration, hand, and eye coordination, fine motor development, gross motor development, help with language and vocabulary mastery, mathematical thinking, scientific thinking, emotional literacy, and social development. Loose parts are available in nature so there is no need to buy them at stores. Loose parts are mostly located in the environment around us.

Loose Parts creates unlimited creative possibilities in learning activities and invites children's creativity. Loose Parts are materials that can be moved, carried, combined, redesigned, separated and put back together in various ways. Through direct experience, teachers can explore a variety of materials that can be incorporated into learning in the classroom (indoor) and in the outdoor play area. Teacher friends can also carry out activities through the seven components of Loose parts by fiddling with, communicating between different loose parts, collaborating with other loose parts components, and using critical thinking skills, and the teacher's imagination in developing learning that uses loose teaching materials Parts.

The natural outdoor environment is an environment for finding loose parts and is an important part of providing play spaces directed at children (Flannigan & Dietze, 2018). Incorporating loose parts teaching materials in early childhood classes provides exceptional opportunities for children to explore the world around them using natural, synthetic, and recyclable materials. Loose-Parts can be an incentive to have meaningful conversations and encourage interaction between students. Through loose-parts, children don't take long to appreciate each other's conversations in their groups. The discussion of loose parts will further foster mutual respect in a multicultural class (Smith-gilman, 2018). Students will express their own experiences in schools, some of which come from members of different cultural environments in multi-ethnic schools. The exchange of students' ideas reflects an awareness of their future role in helping children become good multicultural community members.

2.2 *STEAM in Early Childhood Education*

STEAM approach is considered to benefit the future workforce. The United States of America is one of countries which gives a great emphasis to the need of STEAM-related jobs (Allen, 2016; Dejarnette, 2018). However, STEAM-related jobs are basically relevant to the global context as there is a changing landscape for jobs all around the world. Currently, there are more jobs that require more than reading and counting skills. In addition, STEAM is not merely a matter of workforce or economic issues.

Despite the growing popularity of STEAM, previous studies have disclosed various challenges related to the STEAM practices (Allen, 2016; Moomaw, 2016). There are at least three factors, which might hinder a high-quality STEAM implementation in the classroom. The first factor is the teacher readiness. As most of the studies reported, teachers often stated that teaching STEAM requires more knowledge and support (Allen, 2016; E. McClure et al., 2017; Moomaw, 2012). Secondly, most of the teachers argued that they did not have enough time to integrate STEAM in their lesson plan because they already had too many subject contents to be covered throughout the study year (Allen, 2016). Thirdly, there was a common misconception that STEAM requires expensive and high-tech materials (Ansberry & Morgan, 2019). In response to the challenges, there have been fairly amount of literatures discussing the first and the second challenges. However, study and literatures focusing on the materials used to support STEAM are rarely to be found.

2.3 *The Role of Early Childhood Educators*

In addition, teachers can identify how children's experiences using loose parts will be one of the valuable experiences that children want to re-create their future. The teacher will easily design learning processes and stimulate student involvement to manipulate loose parts. Through the use of loose parts can bring critical thinking, problem-solving and newfound relationships. Material through loose-parts is open-minded not only to encourage conversation about the ideas they have and the identity of loose-parts but also teaches children about the values that make a process of discovery possible (Smith-gilman, 2018). This form of involvement is deep involvement in learning. The use of loose parts can bring out the creativity of children who are more complex than just completing worksheet assignments. Loose parts can provide good support for learning. The use of loose parts can build knowledge by actively involving students in each child and children's interactions with their friends in the learning process. Another benefit of loose parts is that they help express students' ideas, values, emotions, and self-reflection.

The implication of loose parts in learning is to provide justice to all students or provide equal opportunities for all students to engage actively and express their ideas. Loose-parts can provide effective involvement and are a powerful step to help teachers see, listen, think and feel what is experienced by students (Smith-gilman, 2018). Teachers need to develop professional knowledge and observation skills through the selection of appropriate methods and tools that will foster meaningful learning. Loose parts can encourage students to think openly. Loose parts allow for direct use that helps to learn to be seen and felt directly by students. Loose-parts can provoke new discoveries, and conversations about meetings, which can increase students' curiosity, creativity and good attitude towards students (Smith-gilman, 2018).

Many examples of loose parts have been manufactured, for example equipment of various building materials, teaching aids to play dramatically, and simple or structured toys. Maxwell et al. (2008) noted that children's play activities were more varied by using loose parts that were already produced rather than using loose parts (Maxwell, L., Mitchell, M., and Evans, 2008). Kiewra, C., & Veselack, (2016) emphasize the idea that natural ingredients can be anything. Some natural objects require specific treatment however, children are encouraged to be innovative and use them in unique ways, according to their individual needs and interests.

Cloward Drown asserts that loose parts are more dynamic and allow for natural changes in the playing process. Traditional play which initially only uses natural materials for play equipment, over time children will use natural materials that allow children to stimulate creativity (Cloward

Drown, 2014). The importance of natural loose-parts for infants and toddlers that children continue to choose their own activities and natural elements explored showing the ability to focus and attend and show curiosity that attracts their attention and supports their involvement (Veselack, E., Miller, D., & Cain-Chang, 2015, p. 35). In using loose-parts materials with an outside playing background, Sutton, (2011) broadens his initial definition by noting that the more involvement of children using loose-parts, the broader their thinking will be.

Loose parts are preferred by children and teachers in learning, because they are easily available in the surrounding environment. The value of toys and props in the game, children prefer loose-parts such as sticks, blocks, snow, and sand that can be reused to whatever they want (Kiewra, C., & Veselack, 2016). In addition to natural loose-parts, there are also artificial loose-parts such as artificial metals, plastics, and loose parts made of wood, and so on. The closeness of the playroom near nature is very important, and deliberately organizing natural environment items allows children to form stronger bonds and connections with these materials during play (Kuh, L., Ponte, I., & Chau, 2013). Natural goods can be many things as natural items such as leaves, stones, sticks, and berries into paint and paint brushes (Monsalvatge, L., Long, K., & DiBello, 2013). The same material can turn into collages or props for dramatic play with children's books (Gull, Bogunovich, Goldstein, & Rosengarten, 2019).

3 METHODS

2.1 Research Method

This research employs a qualitative method, as the aim is to gain preliminary understanding about STEAM in early childhood context (Silverman in Eeuwijk & Zuzana, 2017). The phenomenology research design was followed in this study because the research question needs a profound understanding from the group of pre-service teacher students who hold common experiences in using loose-parts (Creswell in Padilla-Diaz, 2015). Phenomenology commonly used in various research in education field to hear students or teachers voice (Robison, 2016; Sohn, Thomas, Greenberg, & Pollio, 2017; Yuksel-Arslan, Yildirim, & Robin, 2016). Because the nature of phenomenology design is to see underlying essences and common meanings attributed to the phenomenon, the participants in this study was chosen purposively based on some common criteria.

3.1 *Data collection*

For collecting research data, the Focus Group Discussion (FGD) method was used. This data collection method is appropriate as the aim of this study is to explore participants' ideas, understandings, perceptions, knowledge, and experiences regarding loose-parts and STEAM (Eeuwijk & Zuzana, 2017; Freitas, Oliveira, Jenkins, & Popjoy, 1998; Liamputtong, 2010; O.Nyumba, Wilson, Derrick, & Mukherjee, 2018). FGD was chosen because it is said that FGD is an excellent tool for gaining depth and insight about the subject matter. It aligns with the research design which tries to seek the common meaning from the group of pre-service teacher students who underwent the same experiences in using loose parts for their lessons. FGD is a powerful tool for explaining, clarifying, and providing a better understanding about the subject explored (Mishra, 2016).

3.2 *Procedure*

The research stages consist of four steps which are research design, data collection, analysis, and reporting the results. The research design stage involves the development of key questions, deciding the number of participants, deciding the number of focus groups, finalizing the ethic clearance, selecting a venue, and arranging materials.

The researcher developed eight key questions to answer the research questions. Here are several examples of the questions: "*Do you think the children learn differently when you use loose-parts? Do you think loose-parts can support children's learning in mathematics? If it's so, in what ways? What are the drawbacks of using loose-parts in your lesson plan?*" The key questions intend to answer the research question. However, the FGD questions are different from the research question. It is the researcher's responsibility to formulate appropriate questions in order to answer the research question (Eeuwijk & Zuzana, 2017). After developing the key questions, the researcher recruited eight participants.

The second stage is data collection. In this study, there were three FGD sessions conducted and each session lasted between 45 and 60 minutes. The first FGD was an exploration stage to gain preliminary understandings from the participants regarding loose-parts and STEAM. The second FGD was conducted midway through the research to monitor the process. Finally, the third FGD was done at the end of the project implementation and was meant as an evaluation process (Eeuwijk & Zuzana, 2017).

The FGD results where was audio recorded and transcribed in detail. In the beginning of the analysis process, the transcripts were coded and labelled without limiting the number of codes. In the second step, the researcher conducted a focused coding to eliminate and combine the codes. The researcher used both content and ethnographic analyses to generate main themes without losing the contexts (Freitas et al., 1998; O.Nyumba et al., 2018).

3.3 *Participant*

The participants of this research were eight pre-service teachers who took a course called "Early Childhood Learning Approach". This number of participants was considered adequate as FGD usually involves 6 to 8 people in each group (Liamputtong, 2010). All the pre-service teachers agreed to participate in this study and submitted an agreement form. Even though they were divided into three groups during the loose-parts project implementation, they were involved in the FGD as one group.

During the course, all the participants learnt about various approaches, methods, and models in early childhood learning. One of the focuses is Reggio Emilia approach. This approach is rarely known in Indonesia. However, there is one preschool near Salatiga which has implemented this approach. The researchers shared a story about their practices, which successfully sparked STEAM learning in their students (Siantayani, 2018). The pre-service teachers then learnt to assess students' learning based on the STEAM framework.

After a month exposure to the STEAM course, the pre-service teachers did a loose-parts project. The eight participants were divided into three groups. Two groups consisted of three persons and one group consisted of two persons. During the project, each group got involved in one preschool setting, specifically in three to four-year-old class. There were 3 preschools which took part in this project.

At the beginning of the project, the pre-service teachers observed and were involved in the daily leaning of the three to four-year-old classes for about four weeks. This would give them chances to gain understandings about learning practices in the classroom. In the fifth and the sixth week, the group presented two lesson plans that integrated loose parts and STEAM approach.

Each lesson plan incorporated three main components which were children's literature, invitation, and provocation. At the beginning of each lesson plan, the pre-service teachers would read a children picture book. This book was used to give a context to the next provocation and activities (Monhardt & Monhardt, 2006). There were six children books used for the loose-parts project which were "How to Catch a Star", "Lost and Found", "The Way Back Home", "Giraffe Can't Dance", "The Koala Who Could", and "The Squirrels Who Squabbled".

After the book reading, the loose parts were presented to the children. The pre-service teachers arranged the loose-parts and other materials aesthetically to invite the children to participate. They adopted this practice from the Reggio Emilia approach which perceived the environment as the third teacher (Strong-wilson & Ellis, 2002). In the invitation arrangement, they also posed a provocation for the children related to the picture book. For example, one group read a story about a boy who loved stars and tried to captured them (Jeffers, 2004). The group arranged various seeds, pop sticks, and bottle caps to invite children engagement with the materials and also posed a provocation statements "*Can you make your own star friend*?"

The FGD was conducted before the group delivered the loose-parts project, midway through the project, and after the project was finished. The course content (Reggio Emilia approach and STEAM materials) and the loose-parts project implementation were provided to the participants with similar knowledge and experiences related to the research focus.

4 RESULT AND DISCUSSION

After the pre-service teachers implemented the project, they discussed how loose-parts support the STEAM-based learning. The data analysis revealed two major themes from the discussion: (a) freedom and (b) problem solving.

4.1 *Freedom*

Loose parts gave much of freedom to the students during the learning. The freedom covers three different categories which are freedom in the material selection, freedom during the building up process, and freedom of the product result.

4.1.1 *Freedom in the Material Selection*

One of the most intense topics which came up during the discussion was that loose parts provided ample choices of materials for the children (code T1.6, code T1.9). Prior to the loose-parts project, the typical utilized media in the classroom activities were papers, glue, scissors, and colour pencils. With those kinds of materials, the common learning activities for the children are counting, learning alphabet, and art making the worksheets. Moreover, the art was also limited to cutting and gluing, drawing, or colouring (code T1.6).

The arts education in the classroom context often limited on the visual arts. In Indonesia, other arts areas such as music, drama, and dance are often taught separately as extracurricular activities. However, the FGD revealed that the quality of the visual arts education in the classroom might be low. According to the principles of arts, high quality arts can be obtained if the child have access to a wide variety of art media, thus the children can have meaningful interaction, discovery, inquiry, and exploration (McClure et al., 2017). Based on that principles, merely provided papers cannot be counted as providing material-rich environment thus endanger the quality of the arts education.

During the loose-parts projects, the pre-service teachers provided more than five materials for one activity challenge. The material variation gave children a chance to interact with the materials freely. For example, one pre-service teacher shared her experience during the lesson period. At the beginning of the lesson, she read aloud a story about a boy who explores the moon with his rockets. Later, she invited the children to the loose-parts play. She challenged the children to build their own plane. However, there was a child who was not ready to build the plane. Fortunately, the range of materials provided gave the child a chance to play according to her developmental level. The child did not build a plane, she just played with the big buttons and sorted the big buttons in a very engaging manner (code T1.160). That authenticity of learning might not happen when the teacher just provides one kind of material and then focuses on the end product.

A similar event happened in another setting (code T2.49). The pre-service teachers provoked the children to make a garden. However, the task might be too hard for one young girl. She did not make any garden, but she played with the materials and created her own counting ritual. First, she put mini styrofoam balls inside the straw. Then, she poured the mini balls to the bottle cap while she murmured the number. She repeated the counting pattern for a long time period (put the balls inside the straw – poured the balls to the bottle cap – murmured the number). The pre-service teachers recognized the event as "meaningful mathematics learning". The child practiced her counting skills and create a pattern of a counting ritual (algebra).

If we compare between the typical classroom activities provided by the teacher and the loose-parts play provided by the pre-service teachers, it is clear that the use of loose-parts more likely supports a high-quality arts education. A high quality arts education can provoke creativity (Hui, He, & Ye, 2015). Different kind of materials present a lot of sensorial experiences. The experiences develop artistic and perceptual capacities. Furthermore, the experiences allow children to construct knowledge about their world (Piaget in Berk, 2009). The construction of knowledge through active explorations can be regarded as science education. In Indonesia, especially in early childhood education, the emphasis of the science education is on the science process skills. The science process skills underlines the Indonesia early childhood curriculum and it is called as 'scientific approach' (Rahardjo, 2019). In addition to arts and science, the wide variety of materials presented mathematics learning. The pre-service teachers noticed that even though both of the children did not respond to the activity, they experienced a meaningful mathematics learning. She learned about pattern, number, and geometry. Loose parts supported their authentic learning in mathematics.

4.1.2 *Freedom during the Build Up Process*

Another prominent topic repeatedly said was that loose-parts project freed the children during the process of product creation. The pre-service teachers provided various provocations such as "*Can you build your own plane*" or "*Let's make our flower garden*" but they did not exemplify the making steps to the children. This was contrary to the common classroom practices. One of the pre-service teachers stated that "*The teacher always, always models the steps before they begin the lesson activities*" (code T3. 226). The statement was supported by various evidence gathered from the FGD session.

Firstly, two pre-service teachers observed the classroom teacher prior to their project implementation. The theme was cassava rolls (Indonesian traditional fried food made from cassava leaves). with the students. After the explanation about cassava at the beginning of the lesson, the teacher asked the students to colour a cassava leaf picture using grated coconut that has been coloured using green dye. The teacher modelled how to put the glue on the paper and how to sprinkle the grated coconut on top of the glue (code T1.30).

Secondly, other pre-service teachers encountered similar situation. The teacher asked the children to make rocket from papers. Each child got a set of rocket fin and rocket body. The teacher had cut the pattern for the children. Before the children started, the teacher modelled step by step of the rocket making process. According to one pre-service teacher, there was one child who stuck the fin differently from the model. The teacher pulled out that fin and corrected the position. The teacher controlled the process making as well as the end product. It seemed that the teacher valued uniformity (code T1. 40). Furthermore, in another day, the teacher provided circle-shape papers for making a clown face. Each child got a big circle-shape paper, a small round paper for the nose, clown hat, mouth, and eyes. The teacher modelled the making process and then the children just needed to glue each part of the clown face.

From the excerpt, we can see that the typical classroom activities limited children skills: gluing and colouring (code T1.21). In contrast, the STEAM project presented a degree of freedom during the activities. Thus, it allowed children to practice their diverse skills (code T1.59). Even though the children made the same objects, the process varied from one child to another. For example, after the pre-service teachers read-aloud a story about a boy who brought the lost penguin back to its home, they challenged the children to make their own boat. Most of the boat did have similar features such as mast and sail. However, the different selection of materials resulted in different process. One child chose a big straw as the mast. When he stuck it to the styrofoam board, the mast swayed. He then tested another material: skewer. The skewer was sturdier than the straw.

Why the skewer was sturdier than the big straw? The pre-service teacher did not provoke deeper. However, the child action swapping the straw to the skewer showed that the children observed the objects, tested the properties, and took action. It was possible that he did not understand the scientific concept yet, but the play experience potentially contribute to his science understanding later (Gomes & Fleer, 2019; Sikder & Fleer, 2015).

The freedom of the process making also contributed to the mathematics skills development. It is retold that there was a child who wanted to add a ladder to his boat. He chose pop sticks to make his ladder. Originally, the pop sticks were a way too long. He cut the pop sticks in the same length, then arranged the sticks to make a ladder. The pre-service teachers identified engineering process and mathematics skills such as measurement, algebra, and geometry there. They argued that the child had a vivid picture about what a ladder looks like (understand pattern: algebra and geometry). The child also modified the sticks to meet his need. He did an engineering process and he occupied a simple technology tool (scissors). Apparently, freedom during the process making allows the children to encounter various problems. In other words, the freedom of the process creation is closely related to the problem discovery as well as the problem solving which will be discussed more extensively in the next theme. The problem discovery required the children to use their technological knowledge, engineering, and mathematics skills.

4.1.3 *Freedom of the Product Result*

Finally, loose parts allow variation of the product results made by the children. Loose parts gave children freedom to make their own artefacts. One common practice in most of the classrooms is that the teachers have the end product as an exact model not as an inspiration. It means that most of the art activity will end up with the same product for all the children in the classroom (code T1.40). The previous example revealed how the teacher fixed a rocket fin. It was a class of 4-

year-old children. They were developing their fine motor skills, so that their rocket might not seemed as perfect as the model. However, the teacher made a correction for the child. Even though the rocket looked perfect at the end of the day, there was a remaining question: Did the result show an authentic learning of the children?

Other examples were told by the pre-service teachers. They observed that the theme of the day was about family, particularly 'mother'. The teacher and the children discussed about the role of the mother in the family and asked what their mother look like. After the circle time, the children were directed to do three activities. One of the activities was making a necklace for their mother. The teacher prepared strings, a lot of straw pieces, and different colours of bottle cap. However, she directed how the children should make the necklace in a strict way. The teacher instructed the children to take 5 straw pieces and 5 bottle caps, each of them should had a different colour: orange, green, yellow, dark blue, and light blue. Then, she instructed that the children should put 1 straw to the string, followed by the dark blue bottle cap, followed by another straw pieces, followed by the yellow bottle cap, and so on. There were several children who did not follow the instruction precisely. The teacher scolded them and asked them to rearrange the necklace so that the necklace would have the same patterns as the model.

The pre-service teachers did not really understand why the teacher do that, nor the reason behind her decision. The pre-service teachers reflected that the teacher hindered a great opportunity of mathematics learning. The necklace was a good opportunity for creating pattern. The teacher was also hindered children's creativity. Most of the time, the common art lesson plan was "making something" but the teacher brings a model. The teachers demand the same end product. They often corrected the students throughout the process because they are obsessed with the beauty of the end product based on their standard. The arts and the mathematics learning opportunity reduced to become merely a fine motor skill learning. A high quality arts education leads to creativity (Hui et al., 2015). Creativity is one among the four twenty-first century skill that the children should have (Lindeman & Anderson, 2015). However, there are at least eight underlying principles which are essential for the arts education (McClure et al., 2017). Five out of the eight principles are related to the teacher. A teacher is an important key factor which determines the quality in arts education.

From the result, it was clear that loose parts allow freedom from the beginning up to the end design process. Research in Western countries shows that freedom flourishes creativity (Cheung, 2017). Before the loose-parts project, most of the teachers tend to control children's activities. The classroom practices resemble Chinese preschool classroom, described by Cheung (2017) as 'highly structured'. In a highly structured classroom, teachers usually prepare closed activities and limit the materials. As a result, the art product will be the same for all the students in that classroom.

Meanwhile, the loose-parts project conducted by the pre-service teachers provided freedom. Even though the pre-service teachers brought pictures or sample of the artefacts, the pictures and the artefacts were meant to support children's observation. The pre-service teachers tried not to force the children to follow their ideas and standards. The pre-service teachers demonstrated a good balance between structure and freedom, which is a crucial point in the creative practice (Sawyer, 2006). The balance between structure and freedom will prevent aimlessness activity as feared by Cheung (2017). From the discussion, we can conclude that the highly structured classroom hinders creativity while loose-parts project potentially sparks freedom, a main element of creativity and arts (Liao, 2016).

From the result, it was also obvious that the freedom generated science education. Without forcing the children to imitate the models, the children had to examine carefully the leaning object so that they can produce their own artefacts. For example, when the pre-service teachers provoked them to make their own plane, one child said, "*I can't make a plane*". But then the teacher brought the picture close to him and scaffold his observation. Finally, the child begun to build the plane (code T1.168). The same experience happened when the pre-service teacher provoked the children to make their own garden. In the absence of a garden model, one of the children wandered around and observed a flower before she made the flower artefact for her garden (code T2.17). The degree of freedom presented by the loose-parts gave many opportunities for enhancing children's science process skills such as observation, inferring, and communication (Can, Yildiz-Demirtas, & Altun, 2017; Monhardt & Monhardt, 2006; Padilla, 1990). Furthermore, the degree of freedom also supports technology and engineering learning. Different kinds of materials lead to different process making. The children need to observe, try, test, and adjust the process based on different material property.

The initial question which tried to be answered in this study is "how the use of loose-parts supports science, technology, engineering, arts, and mathematics in children's learning?" Based on the discussion, the first theme emerged was that loose-parts support freedom during the learning activities. The freedom ignited authentic mathematics, science, technology, engineering, and art learning.

4.2 *Problem solving*

Another prominent theme that came up from the FGD was that loose parts allowed the children to face various problems, especially during the making process (code T1.44). The pre-service teachers felt a big difference before and after the STEAM project. Before the STEAM project, the children typically learn to count, write alphabet, cut and glue pattern. Most of the activities were using papers as the main media. There media was so poor, and it made the learning so boring. However, the loose parts presented rich opportunities of exploration, imagination, and discoveries in children's learning.

One pre-service teacher shared her experience with the children during the learning. She challenged the children to make their own plane. One child said that he could not make it. At her first attempt to persuade the child, the pre-service teacher said, "you can do it". However, the child still could not do it just because he was encouraged. The pre-service teacher changed her strategy. She realized that the difficulties of making a plane might be due to child's weak concept of the plane. She brought the plane miniature closely to the child and scaffolded the child. She asked the child to observe the miniature, asked the child what he knew about plane's feature, what shape was that, what kind of materials that he might use to make that part of the plane, and how he could attach one material to another. After that, the child was eager to make his own plane. At first, he chose big buttons as the plane's wheel, but he had difficulties to attach the button to the plane's body (a paper coffee cup). After several attempt, he took a rectangle paper box, attached the button to the paper box, then attached the paper box to the paper coffee cup.

The pre-service teacher reflected on that experience and said that science underlies engineering and technological learning. She realized that engineering process of making a plane would not be possible if the child did not have a clear concept about what plane is. Furthermore, different kinds of materials posed various problems during the making process. If the child chose a bottle cap as the plane wheel, he might need to use another strategy to attach it to the plane body. Loose-parts gave children a lot of opportunities to encounter problems, thus loose-parts also presented a wide opportunity to do problem solving.

Other preservice teachers also highlighted many episodes when the children confronted with problems during the learning activities. One pre-service teacher told that there was a child who wanted to attach the bottle to the wooden stick. She failed many times. At the end, she changed the glue with the white tape and wrapped it around the bottle and the stick. "*The mast is firm now*", she said.

Another pre-service teacher revealed story about a child who want to use straw as his boat mast. However, the straw collapsed many times. He learnt and observed his friend who encounter the same problem. He noticed that his friend changes the straw to skewer. Based on his observation, he took a skewer, stuck it to the styrofoam, and then covered the skewer with the straw (code T1. 94).

The problem with the mast and the straw was also experienced by another child. The child uses a thin styrofoam as his main boat body. When he stuck the mast to it, the mast swayed all the time. However, instead of swapping the straw to the skewer, he modified the Styrofoam. He took another styrofoam, cut it smaller than his prior Styrofoam, and put it on top of the previous styrofoam. As a result, he got a thick main body boat. Thus, when he stuck the mast again, the styrofoam held it firmly (code T1.96).

Before the loose-parts project, the teachers tend to limit the materials. It made the children less exposed to problems. As it was clear from the FGD excerpt, different kind of materials presented more challenge during the making process. Therefore, the engineering was initiated. One of the dimension of engineering process is about how to make a thing (Bagiati & Evangelou, 2015; Becker & Park, 2011; Goris & Dyrenfurth, n.d.). Children engineered materials into some products using simple technology tools such as glue or cutter. They also embedded technology into their products: a plane that has wheels, a ladder to climb a tree, or a fence around their flower garden.

Engineering and technology is closely related (Becker & Park, 2011; Lachapelle et al., 2019). For example, if the teacher provides materials other than the grated coconut and one kind of glue, there might be one or two materials that are hard to be attached to the paper. Children may try different glue and chose which glues is strong enough to attach the materials to the paper. The teacher can intently provoke children to explore the glue. Glue as well as scissors are most commonly used technological tools in the preschool classroom. Students and teachers often take them for granted. In fact, exploration of different kinds of glues and scissors might expose students to different kinds of technology. Teachers can tell a story about the history of glue or scissors. Who knows, someday one of the students may create another kind of scissor to cut some materials that currently cannot be cut yet.

However, teacher's misconception about technology often hinders technology education in the classroom. Technology is often associated with modern electronic devices (Fleer, 1998; Jarvis & Rennie, 1996; Lachapelle et al., 2019; Rocha Fernandes et al., 2018). Another common misconception about technology is that people often mix up the term 'educational technology' and 'technology education'. Educational technology focus on the use of technology in education. In this context, technology act as a tool to support and enhance students' learning process. On the other hand, 'technology education' means the students have a change to learn about technology. Technology education deliberately involve students to learn about processes and knowledge about technology. Technology education aim to make the students gaining a technological literacy (Dugger & Naik, 2001)

Furthermore, the pre-service teachers identified teachers' habit to solve the problem for the children. In the usual classroom practices, children are rarely allowed to do a problem solving. One of the pre-service teachers said that most of the time, the teacher would come and helped the children when the children having difficulties doing the instruction (code, T2. 198). "The teachers tend to solve the problem for the children" (code T1.125, code T1.143, code T2.131). Some of the reasons might be because they want the students succeed in finishing the tasks on time. One of the participants mentioned that "*I think the teacher wanted to stick to the daily schedule such as lunch time*" (Dian, T2.202). The pre-service teachers predicted one of the reasons why teachers tend to solve the problem for the children is because they want to stick to the schedule.

Another excerpt came from one pre-service teachers who valued loose-parts in supporting problem solving skills. In one lesson, she observed that the teacher asked the children to paint a tree using two fingers. Some of the children could not do it but the teacher forced them. She grabbed the student's fingers and moved the fingers. The pre-service teacher stated that "*It's different with our loose-part project. We did not solve the problem for the children. We just provoked them until they could solve their problems*" (code T1. 143).

There was another story told. The pre-service teacher observed that the classroom teacher and the children were going to make snow. During the process, a child poured too much water on the dough. After that, the teacher came and add more baking powder then asked the child to knead it again. The pre-service teacher said that actually that accident (too much water) was a good problem to be solved by the children. She said "*I think the teacher should prompt with questions first, not just solved the problem for the child*" (code, T2. 131).

The excerpts present a vivid illustration of how the use of loose parts supports STEAM education, especially the engineering and technology education. Loose parts provide children opportunities to deal with many problems, especially in the making process. When children tried to solve the problems, they were exposed to the engineering as the process of problem solving is the heart of the engineering practices (Park, Park, & Bates, 2018).

The use of loose parts facilitates children with various engineering processes. The vignettes showed various engineering processes. Emergent engineering is defined as children solving problems through multiple trial-errors because they might not have correct concepts yet (Park et al., 2018). For example, Arty solved the swayed mast problem by trial-error process. First, he used the thin styrofoam but soon realized that thicker styrofoam held the mast better. According to NGSS in Park, Park, and Bates (2018), there are three phases of engineering design practices which are 'defining and delimiting engineering problems', 'designing solutions to engineering problems', and 'optimizing the design solution'. Most of the children in the project were in the phase 1 and 2. The pre-service teachers did not have the opportunities to scaffold children into the third phase as they just had one day to do their loose-parts project. The teachers are the important and significance factor for the success of the third phase (Bagiati & Evangelou, 2015).

Furthermore, the children were also exposed to technology as technology and engineering are closely related. In the activities, simple technology tools are used to manipulate the materials to meet the design objectives. In this case, children had demonstrated the goal of technology stated in the National Science Education Standards – NSES (National Research Council, 1996) which are modifying to meet human needs.

The second theme: “problem solving” also gives a quite clear answer to the initial question: “how the use of loose-parts supports science, technology, engineering, arts, and mathematics in children’s learning?” Based on the discussion, loose parts presented many problems to the children. To solve the problems, children need to observe carefully things, events, or processes. Observation is one of the science process skills. After careful observation, they might predict, do something, and infer their action. The problem-solving process relates closely to engineering and technology. At some point, they might use their mathematics skills as well. Therefore, we can conclude that loose-parts creates problems, thus loose-parts supports science, mathematics, engineering, and technology learning.

5 CONCLUSION

Loose-parts are potential media to support STEAM learning in children as the use of loose-parts generates freedom and various problems to be solved. A diverse range of loose-part materials allow children to examine the materials properties carefully. The use of loose parts ignites their observation skills. Besides, the children had a chance to play with the materials. The use of loose-parts assist mathematics learning. The FGD excerpts indicate that various mathematics skills demonstrated during the learning process where the children responded to the teachers’ provocation or played the materials their way. Some of the evident mathematics skills incorporated in their learning process are measurement, patterns (algebra), geometry, and number operation.

Furthermore, the freedom of the material selection allowed the children to choose the most proper materials to meet their design objectives. The freedom of the product design gave the children an opportunity to communicate their authentic learning. They experience a meaningful arts education. Arts became their communication of learning. The use of loose parts allow creativity which serves as a main component in arts education.

At the same time, the freedom provides many problems to be solved. Different materials present different problems. Children were encouraged to observe, try, and then decide which kind of materials to be chosen. That decision was a result of the children’s inference process. It can be concluded that the freedom supports arts education and science process skill development such as observation, inference, and communication. The freedom and the problems also support engineering and technology integration into children’s learning.

6 REFERENCES

Allen, A. (2016). Don’t Fear STEM: You Already Teach It! *Exchange*, (231), 56–59.

Ansberry, B. K., & Morgan, E. (2019). *Seven Myths of STEM*. *56*(6), 64–67.

Bagiati, A., & Evangelou, D. (2015). Engineering curriculum in the preschool classroom: the teacher’s experience. *European Early Childhood Education Research Journal*, *23*(1), 112–128. https://doi.org/10.1080/1350293X.2014.991099

Becker, K., & Park, K. (2011). *Effects of integrative approaches among science , technology , engineering , and mathematics (STEM) subjects on students ’ learning : A preliminary meta-analysis*. *12*(5), 23–38.

Berk, L. E. (2009). *Child Development* (8th ed.). Boston: Pearson Education.

Can, B., Yildiz-Demirtas, V., & Altun, E. (2017). *The Effect of Project-based Science Education Programme on Scientific Process Skills and Conception of Kindergargen Students*. *16*(3), 395–413.

Casey, T., Robertson, J., Abel, J., Cairns, M., Caldwell, L., Campbell, K., … Robertson, T. (2016). *Loose Parts Play*. Edinburgh.

Cheung, R. H. P. (2017). Teacher-directed versus child-centred : the challenge of promoting

creativity in Chinese preschool classrooms. *Pedagogy, Culture & Society*, *1366*(January), 1–14. https://doi.org/10.1080/14681366.2016.1217253
Clements, D. H., & Sarama, J. (2016). Math, Science, and Technology in the Early Grades. *The Future of Children*, *26*(2), 75–94.
Cloward Drown, K. (2014). *Dramatic lay affordances of natural and manufactured outdoor settings for preschoolaged children*.
Dejarnette, N. K. (2018). Early Childhood Steam: Reflections From a Year of Steam Initiatives Implemented in a High-Needs Primary School. *Education*, *139*(2), 96–112.
DiGironimo, N. (2011). What is technology? Investigating student conceptions about the nature of technology. *International Journal of Science Education*, *33*(10), 1337–1352. https://doi.org/10.1080/09500693.2010.495400
Dugger, W. E., & Naik, N. (2001). Clarifying Misconceptions between Technology Education and Educational Technology. *The Technology Teacher*, *61*(1), 31–35.
Eeuwijk, P. Van, & Zuzana, A. (2017). *How to Conduct a Focus Group Discussion (FGD) Methodological Manual*.
Flannigan, C., & Dietze, B. (2018). Children, Outdoor Play, and Loose Parts. *Journal of Childhood Studies*, *42*(4), 53–60. https://doi.org/10.18357/jcs.v42i4.18103
Fleer, M. (1998). The Preparation of Australian Teachers in Technology Education : Developing The Preparation of Australian Teachers in Technology Education : Developing Professionals Not Technicians. *Asia-Pacific Journal of Teacher Education & Development*, *1*(2), 25–31.
Freitas, H., Oliveira, M., Jenkins, M., & Popjoy, O. (1998). The focus group, a qualitative research method: Reviewing the theory, and providing guidelines to its planning. In *ISRC, Merrick School of Business, University of Baltimore (MD, EUA)* (Vol. 1).
Gomes, J., & Fleer, M. (2019). The Development of a Scientific Motive : How Preschool Science and Home Play Reciprocally Contribute to Science Learning. *Research in Science Education*, *49*(2), 613–634. https://doi.org/10.1007/s11165-017-9631-5
Goris, T., & Dyrenfurth, M. (n.d.). *Students ' Misconceptions in Science , Technology , and Engineering* .
Gull, C., Bogunovich, J., Goldstein, S. L., & Rosengarten, T. (2019). Definitions of Loose Parts in Early Childhood Outdoor Classrooms: A Scoping Review. *The International Journal of Early Childhood Environmental Education*, *6*(3), 37.
Hui, A. N. N., He, M. W. J., & Ye, S. S. (2015). Arts education and creativity enhancement in young children in Hong Kong. *Educational Psychology*, *35*(3), 315–327. https://doi.org/10.1080/01443410.2013.875518
Jarvis, T., & Rennie, L. J. (1996). Perceptions about Technology Held by Primary Teachers in England. *Research in Science & Technological Education*, *14*(1), 43–54. https://doi.org/10.1080/0263514960140104
Jeffers, O. (2004). *How to Catch a Star*. New York: Philomel Books.
Kiewra, C., & Veselack, E. (2016). Playing with nature: Supporting preschoolers' creativity in natural outdoor classrooms. *International Journal of Early Childhood Environmental Education*, *4*(1), 70–95.
Kuh, L., Ponte, I., & Chau, C. (2013). The impact of a natural playscape installation on young children's play behaviors. *Children, Youth and Environments*, *23*(2), 49–77.
Lachapelle, C. P., Cunningham, C. M., & Oh, Y. (2019). What is technology? Development and evaluation of a simple instrument for measuring children's conceptions of technology. *International Journal of Science Education*, *41*(2), 188–209. https://doi.org/10.1080/09500693.2018.1545101
Liamputtong. (2010). Focus Group Methodology : Introduction and History. In *Focus Group MethodoloGy* (pp. 1–14).
Liao, C. (2016). *From Interdisciplinary to Transdisciplinary: An Arts-Integrated Approach to STEAM Education*. *69*(6), 44–49. https://doi.org/10.1080/00043125.2016.1224873
Lindeman, K. W., & Anderson, E. M. (2015). Using Blocks to Develop 21st Century Skills. *Young Children*, *70*(1), 36–43.
Maxwell, L., Mitchell, M., and Evans, G. (2008). Effects of play equipment and loose parts on preschool children's outdoor play behavior: An observational study and design intervention. *Children, Youth and Environments*, *18*(2), 36–63.

McClure, E., Guernsey, L., Clements, D., Bales, S., Nichols, J., Kendall-Taylor, N., & Levine, M. (2017). How to Integrate STEM Into Early Childhood Education. *Science and Children*, *055*(02), 8–11. https://doi.org/10.2505/4/sc17_055_02_8

McClure, M., Tarr, P., Thompson, C. M., & Eckhoff, A. (2017). Defining quality in visual art education for young children: Building on the position statement of the early childhood art educators. *Arts Education Policy Review*, *118*(3), 154–163. https://doi.org/10.1080/10632913.2016.1245167

Mishra, L. (2016). Focus Group Discussion in Qualitative Research. *TechnoLearn: An International Journal of Educational Technology*, *6*(1), 1. https://doi.org/10.5958/2249-5223.2016.00001.2

Monhardt, L., & Monhardt, R. (2006). Creating a context for the learning of science process skills through picture books. *Early Childhood Education Journal*, *34*(1), 67–71. https://doi.org/10.1007/s10643-006-0108-9

Monsalvatge, L., Long, K., & DiBello, L. (2013). Turning our world of learning inside out! *Dimensions of Early Childhood*, *41*(3), 23–30.

Moomaw, S. (2012). STEM begins in the early years. *School Science & Mathematics*, *112*(2), 57–58.

Moomaw, S. (2016). Move Back the Clock, Educators: STEM Begins at Birth. *School Science & Mathematics*, *116*(5), 237–238.

Moomaw, S., & Davis, J. A. (2010). STEM Comes to Preschool. *Young Cihildren*, *12–18*(September), 12–18.

Munawar, M., Roshayanti, F., & Sugiyanti. (2019). Implementation of STEAM (Science, Technology, Engineering, Art, Mathematics)-Based Early Childhood Education Learning in Semarang City. *Jurnal CERIA*, *2*(5), 276–285.

National Research Council. (1996). *National Science Education Standards*. Washington, DC: National Academy of Sciences.

Nicholson, S. (1972). The Theory of Loose Parts: An important principle for design methodology. *Studies in Design Education Craft & Technology*, *4*(2), 5–12.

O.Nyumba, T., Wilson, K., Derrick, C. J., & Mukherjee, N. (2018). The use of focus group discussion methodology: Insights from two decades of application in conservation. *Methods in Ecology and Evolution*, *9*(1), 20–32. https://doi.org/10.1111/2041-210X.12860

Padilla-Diaz, M. (2015). Phenomenology in Educational Qualitative Research : Philosophy as Science or Philosophical Science ? *International Journal of Educational Excellence*, *1*(2), 101–110.

Padilla, M. J. (1990). The Science Process Skills. *Research Matters - to the Science Teacher*, *1*(March), 1–3.

Park, D. Y., Park, M. H., & Bates, A. B. (2018). Exploring Young Children's Understanding About the Concept of Volume Through Engineering Design in a STEM Activity: A Case Study. *International Journal of Science and Mathematics Education*, *16*(2), 275–294. https://doi.org/10.1007/s10763-016-9776-0

Rahardjo, M. M. (2019). Implementasi Pendekatan Saintifik Sebagai Pembentuk Keterampilan Proses Sains Anak Usia Dini. *Scholaria: Jurnal Pendidikan Dan Kebudayaan*, *9*(2), 148–159. https://doi.org/10.24246/j.js.2019.v9.i2.p148-159

Robison, T. (2016). Male Elementary General Music Teachers : A Phenomenological Study. *Journal of Music Teacher Education*, *26*(2), 77–89. https://doi.org/10.1177/1057083715622019

Rocha Fernandes, G. W., Rodrigues, A. M., & Ferreira, C. A. (2018). Conceptions of the Nature of Science and Technology: a Study with Children and Youths in a Non-Formal Science and Technology Education Setting. *Research in Science Education*, *48*(5), 1071–1106. https://doi.org/10.1007/s11165-016-9599-6

Sawyer, R. K. (2006). *Educating for innovation*. *1*(2006), 41–48. https://doi.org/10.1016/j.tsc.2005.08.001

Sharapan, H. (2012). ERIC - From STEM to STEAM: How Early Childhood Educators Can Apply Fred Rogers' Approach, Young Children, 2012-Jan. *Young Children*, *67*(1), 36–40.

Siantayani, Y. (2018). *STEAM: Science-Technology-Engineering-Art-Mathematics*. Semarang: SINAU Teachers Development Center.

Sikder, S., & Fleer, M. (2015). Small Science : Infants and Toddlers Experiencing Science in

Everyday Family Life. *Research in Science Education*, *45*(3), 445–464. https://doi.org/10.1007/s11165-014-9431-0

Smith-gilman, S. (2018). The Arts, Loose Parts and Conversations. *Journal of the Canadian Association for Curriculum Studies*, *16*(1), 90–103.

Sohn, B. K., Thomas, S. P., Greenberg, K. H., & Pollio, H. R. (2017). Hearing the Voices of Students and Teachers : A Phenomenological Approach to Educational Research. *Qualitative Research in Education*, *6*(2), 121–148. https://doi.org/10.17583/qre.2017.2374

Strong-wilson, T., & Ellis, J. (2002). Children and Place : Reggio Emilia's Environment as Third Teacher. *Theory into Practice*, *46*(1), 40–47.

Sutton, M. J. (2011). In the hand and mind: The intersection of loose parts and imagination in evocative settings for young children. *Children, Youth and Environments*, *21*(2), 408–424.

Tippett, C. D., & Milford, T. M. (2017). Findings from a Pre-kindergarten Classroom: Making the Case for STEM in Early Childhood Education. *International Journal of Science and Mathematics Education*, *15*, 67–86. https://doi.org/10.1007/s10763-017-9812-8

Tippett, C., & Milford, T. (2017). STEM Resources and Materials for Engaging Learning Experiences. *International Journal of Science & Mathematics Education*, *15*(March), 67–86. https://doi.org/10.1007/s10763-017-9812-8

Veselack, E., Miller, D., & Cain-Chang, L. (2015). Raindrops on noses and toes in the dirt: infants and toddlers in the outdoor classroom. *Dimensions Educational Research Foundation*.

Yuksel-Arslan, P., Yildirim, S., & Robin, B. R. (2016). A phenomenological study : teachers ' experiences of using digital storytelling in early childhood education. *Educational Studies*, *42*(5), 427–445. https://doi.org/10.1080/03055698.2016.1195717