Exploring STEAM teaching in preschool using

*Fred Rogers* Approach

**Zahiroh Awang1, Nooraida Yakob2, Aswati Hamzah3, Mohd Mernan Talling4**

1,2,3,4School of Educational Studies, Universiti Sains Malaysia, Malaysia

|  |  |  |
| --- | --- | --- |
| **Article Info** |  | **ABSTRACT**  |
| ***Article history:*** |  | STEAM is an abbreviation of Science, Technology, Engineering, Art and Mathematics. The culture of STEAM teaching is still new among preschool teachers. Nevertheless, STEAM teaching is seen as challenging to be implemented if there is no clear guideline prepared by qualified experts. Therefore, a need analysis on STEAM teaching strategies ought to be conducted so that the need of STEAM teaching may be addressed and its related problems may be attended to. Hence, this research aimed at exploring experts’ perceptions about Fred Rogers’ STEAM as a STEAM teaching strategy that is appropriate to be taught in preschools. This need analysis employed semi structured interviews with experts. The obtained findings were categorized and analysed thematically. Five themes managed to be identified: (1) features and needs of STEAM education, (2) inquiry based learning (3) learning by doing activities, (4) interesting and systematic teaching strategies and (5) suitability with children’ development and practices. The research findings may be benefitted by teachers in ensuring the selection and execution of STEAM teaching strategies are based on experts’ opinion. Besides, it is anticipated to help teachers to conduct meaningful and effective STEAM teaching with preschool students.  |
| ***Keywords:***Preschool educationSTEAM teaching*Fred Rogers’* STEAMNeed analysis |
| *This is an open access article under the* [*CC BY-SA*](https://creativecommons.org/licenses/by-sa/4.0/) *license.* |
| ***Corresponding Author:***Zahiroh Awang, School of Educational Studies, Universiti Sains Malaysia, 11800 Penang, Malaysia.Email: merza2407@mail.com |

1. **INTRODUCTION**

Ministry of Education (MOE) Malaysia has outlined the need of teaching Science, Technology, Engineering and Mathematics or STEM to students beginning from the early stage or preschools (PPPM 2013-2025). The primary of STEM field has made the curriculum makers and teachers aware of the new need that the current students are to be equipped in accordance with the change in work force and the technology driven future (Gunn, 2018). Hence, the development of the 21st century education is believed to be able to bring the aim of STEM Education to a reality. In fact, it is seen able to produce a creative STEM innovator who is capable of charting an excellent future of the country.

Therefore, the stakeholders have begun to enhance the STEM Education system. Several scholars have identified that integrating arts element in STEM brings about fun learning especially in the context of preschool education (Sharapan, 2012; Katz, 2010). Children are believed to have built-in art elements within them. With arts, they are allowed to share ideas through social activities, language arts, fine arts, music and creative movements (Sharapan, 2012; Yakman, 2010).

According to Edwards (2006), visual art is a component out of five art components which include a) literature, b) drama, c) music, d) dance and e) visual arts. Visual arts have the potential to increase students’ cognitive abilities to learn STEM. Children express their feelings and thinking through visual art activities by creating two-dimensional visual work like drawing, painting and printing, thus the three-dimensional art work like creating a model, sculpture and building (Edwards, 2006). Arts, in a way, help them think and understand life in creative ways (Sousa & Pilecki, 2013; Sharapan, 2012; Katz, 2010).

Therefore, the need of integratingarts in STEM is vital (Robelen, 2011; Sharapan, 2012; Tarnoff, 2010; Piro, 2010; Van Meeteren & Zan, 2010). With arts, children become more successful in understanding STEM (Schirrmacher, 2002; Wynn & Harris, 2012)*.* This is because they do love building, drawing and creating something as to record their own learning experiences. Arts enable them to easily understand and express various STEM concept ideas and these are possible through activities like building blocks, manipulating clay, dramatic games, drawing and dancing to music (Karen W. Lindeman, Michael Jabot & Mira T. Berkley (2016).

All materials and tools for art activities which may support STEM initiative have been prepared in preschool classes. Nevertheless, preschool children need to be allocated extended time as they need to explore the learning materials so as to build their creativity characters (Gordon, 2011). Art activities allow them to be imaginative and creative besides helping them to enhance their skills of space and perspective. These are made possible when pupils be allowed to freely explore their learning materials. Limitless exploration may promote engineering skills that pupils may eventually use the technology to create innovation (Katz, 2010). Each of these skills is needed by engineers and scientists in technology development, especially with regard to the country’s future.

The integration of A (Arts) into STEM has developed a new concept known as STEAM (Sharapan, 2012). In the context of preschools, STEAM means a process of teaching Science (S) that integrates the elements of Technology, Engineering, Art and Mathematics (TEAM). STEAM enables pupils to learn how arts are parts of the process in inventing products related to Science, Technology, Engineering and Mathematics. STEAM prepares many possible ways for children to be creative in the context of real-world experiences. Pupils are given spaces to find out, explore, inquire and create using Science and Mathematics. Teachers, too, may expand their experiences in relation with Engineering and Technology. Besides, pupils may be able to enhance the 21st skills when arts are integrated into STEM as a way to communicate and portray Engineering and Technology (Karen W. Lindeman, Michael Jabot & Mira T. Berkley, 2016).

Of this effort, teachers need to exercise STEAM beginning from preschool stage by paying attention to two aspects (Karen W. Lindeman, Michael Jabot & Mira T. Berkley (2016). The first aspect is the use of materials appropriate with the pupils’ growth and the second aspect is the preparation of a learning environment that is meaningful to the pupils. There are numerous tools that teachers may use together with the pupils in instilling skills in Science, Mathematics and Engineering. Nonetheless, what matters more is the teachers’ ability to deliver meaningful experiences to the pupils and to allow them the opportunity to utilize the tools optimally.

Gardon and Browne (2011) explain an environment that is appropriate for kids in three main aspects: (a) time, (b) interpersonal and (c) physical space. These three aspects are essential to be taken into consideration when developing the basis of STEAM among the students. First, the time for pupils to invent is very important. Pupils need quite a long time to invent something. Pupils’ learning time is not structured and flexible. They need to be encouraged to make decisions in relation with games and tasks during free activities. Second, an interpersonal community class is to be taken into account when setting an environment that promotes STEAM in preschools. Hence, teachers have to prepare the ambience of exploration and finding which may enhance students’ 4C skills: Communication, Creativity, Critical Thinking and Collaboration.

Teachers play the role of a model by explaining the activities and become an expert when assisting pupils with their exploration and investigation. Teachers may ask open ended and closed ended questions to the pupils. Children start to think critically when they are given good and meaningful stimuli regarding their world and inventions. Good questions may not only have one answer and the provision of a wrong answer is not a priority to fulfill. Teachers allow pupils to explore their own learning. They encourage the pupils to participate in meaningful discussions and develop pupils’ thinking by asking provoking questions. This is crucial as to let pupils experience their self worth where communication is valued and mistakes are allowed.

Third, physical environment has to be adjusted according to the pupils’ interests and needs. Teachers may exploit the physical environment to ensure students get exposed to various tools used in the real world everyday living. For instance, teachers may place a white board, paper and writing tools in the learning centre so that pupils may feel encouraged to plan, draw, observe and label. Besides, teachers may provide access to sources like meaningful books, pictures and websites which are related to certain topics and are able to expand pupils’ thinking ability regarding the world around them.

In brief, the STEAM teaching process requires commitment and attention among the teachers. It is vital that teachers master the STEAM pedagogical knowledge so that the teaching process may be effectively conducted. Therefore, it is believed that teachers should be equipped with a guideline of STEAM teaching execution in order to meet the aspiration. In line with that, this paper aims to introduce a systematic guideline of STEAM teaching execution (Sharapan, 2012) that is of Fred Rogers’ STEAM.

**1.1 Literature review**

The concept of Fred Rogers’ STEAM is a thinking means facilitated by questions and investigations (Sharapan, 2012). Fred Rogers’ STEAM applies the inquiry based learning so that children are moulded to be a constructor of knowledge and theory. They are to navigate their own learning through questions posed to them and their own discoveries of answer. They, too, share and respond to what they learn, besides mastering their learning according to their development levels beginning from remembering to inventing. The children learn to collect, criticize, analyse and interpret information, create working theories, construct new questions, justify with evidences and integrate new ideas through inquiry based learning. This inquiry based learning is essential in putting STEAM Education in the next level (Gunn, 2018).

STEAM is discovered by the children as they learn and comprehend the world and when they interact with their surroundings. They are exposed to real world environment to provoke their inquisitiveness about life. They are given opportunities to explore and investigate using their own senses (Sharapan, 2012; Katz, 2010). This activity allows them to collect, arrange, observe, note, sketch, interview and review anything related to certain topics or incidents. STEAM encourages children to think as they need to inquire and find answers in solving the problems (Sharapan. 2012).

According to Sharapan (2012), the first letter that is the letter S in the abbreviation STEAM stands for Science. Science exposes pupils to scientific investigation activities. Children act as investigators who collect information related to their everyday living experience. They use their senses to observe, form questions, predict, investigate and discuss their findings. Science may be optimally applied through investigating the living world, physical world and material world (National Preschools Standard Curriculum, 2016c).

Second, T stands for Technology. Technology refers to any object invented by human beings. Technology to children is related to tools or objects that are usable for investigations. The interaction between technological tools and children may enhance their cognitive development. Children learn about functions, reasons and consequences of using technological tools throughout their lives. Third, E refers to Engineering. Children are naturally engineers. They learn to identify the problem and seek for initiatives to solve the problem according to their own creativity. To illustrate, children learn to build a strong house model using blocks (lego). They learn to make the house base, walls, beams, roof, windows and doors and they finally combine all the structures to build a house model.

Fourth, the letter A resembles the word Art. Art is a form of sense exploration and it is active in children. Every children possesses the Art characteristic which may be used to interpret any situation using symbols as to resemble the real objects, events or feelings. Drawing, role playing, music and dancing are media for children to express their creative characters. The last letter, or the letter M stands for Mathematics. Children explore Mathematics through identifying quantity – many or little, shapes, sizes, sequence and distance of objects. Activities like determining similarities and differences, sequencing, measuring and calculating are among high order thinking skills in Mathematics which may be instilled in children.

The STEAM integrated teaching as postulated by Fred Rogers is executed through three main steps - (1) STEAM language conversation, (2) finding STEAM everywhere and (3) STEAM in the future (Sharapan, 2012). Step one is begun by executing active STEAM language conversations with children every day. This activity may be conducted through puppet storytelling, animation, singing and story books. The conversations between teachers and pupils help expand the pupils’ vocabulary and existing knowledge related to Science, Technology, Engineering, Art and Mathematics.

After introducing to pupils the concept and ideas related to STEAM topic (so as to instill interest in students), the second step requires teachers to guide pupils to act as STEAM investigators. Fred Rogers (as cited in Sharapan, 2012) conducts activities of finding STEAM everywhere. This step is important in order to ensure the introduced STEAM topic can be investigated and researched upon in-depth. Therefore, teachers need to prepare authentic environment to trigger pupils’ inquisitiveness so that they are able to learn better. Appropriate tools, materials and media related to the STEAM topic are exposed to pupils in order to excite the pupils in natural ways. The interaction that occurs between pupils and the tools is expected to enable pupils to make new discoveries which then trigger inquiries in their minds. Such experiences and discoveries make pupils become more confident to ask questions and express their opinions pertaining to the activities conducted. STEAM experts are individuals who are responsible of helping pupils in handling various answers for the questions inquired. With the guidance provided by the STEAM experts, pupils are able to meaningfully engage in the learning process. This meaningful learning may hence inculcate interest and basic knowledge of STEAM amongst the pupils.

The third step is known as STEAM in the future. This step is aimed at enhancing pupils’ interest in becoming a STEAM inventor in the future. Therefore, pupils will be exposed to the processes of problem identification and invention of a solution to the problem through a STEAM project. This project is the final activity to reinforce pupils’ understanding towards STEAM knowledge which has been explored in steps 1 and 2.

**1.2 Situation of STEAM Education**

Malaysia, in its pace towards becoming a developed country, has begun focusing on STEAM Education in order to enhance the field of STEM Education which has been earlier implemented since the last few years (Suraya, Norsalawati & Nasir, 2017). In line with the effort, STEAM Education has been rendered to teachers so as to make them aware of its importance (Kartini, Ahamad Shabudin, Tajul Effandy and Azizah, 2018). However, despite having the awareness, the teachers’ confidence level in executing STEAM Education in their classrooms is still low (Tajul Effandy, 2018). This is probably due to lack of understanding of the STEAM concept among the teachers, especially of preschool stage (Jamil, Linder and Stegelin, 2018; DeJarnette, 2018; Sharapan, 2013).

This may be due to limited evidences and resources on STEAM conceptualisation that can be referred to by teachers (Kim & Park, 2012a; Miller & Knezek, 2013). Kang et al., (2012) admit that teachers are not equipped with a complete guideline on teaching STEAM. Hence, teachers may not be able to understand clearly the concept of STEAM and this results in difficulty in STEAM pedagogical practices. In line with this, teachers, too are still challenged to master STEAM pedagogical knowledge (Jamil, Linder and Stegelin, 2018; DeJarnette, 2018; Sharapan, 2013).

With the addition of Art element in STEM, it is discovered that STEM knowledge may be delivered to pupils in a fun way. STEM concepts can be conveyed to students through art activities like singing, dancing, drawing and storytelling. Nevertheless, even though STEAM Education allows teachers to deliver STEAM education in various creative ways, there are still many teachers who are unable to execute STEAM teaching well (Jamil, Linder and Stegelin, 2018; DeJarnette, 2018; Sharapan, 2013). This may be the result of insufficient learning materials that may be referred to by teachers. This lack of resources has possibly caused drawbacks in STEAM teaching among teachers.

**1.3 Research objectives**

This writing aims at exploring STEAM teaching strategy that is appropriate to be practiced by preschool teachers. This research proposes Fred Rogers’ approach as one of the 21st century teaching strategies to be learnt and practised by preschool teachers in order to enhance their STEAM pedagogical knowledge (Sharapan, 2012). Referring to Table 1.1, teachers can systematically and easily execute STEAM teaching activities.

|  |  |  |
| --- | --- | --- |
| **Steps** | **STEAM Teaching Activities** | **Explanation** |
| 1. STEAM language conversation
 | * 1. Practising STEAM language conversation every day
 | Active conversation practice between teachers and pupils regarding their existing knowledge on certain topics. For example, discuss about a butterfly life which includes size, colour, shape, movement, food and living period (all are related to STEAM concept). |
| 1. Finding STEAM everywhere
 | * 1. Building while exploring the surrounding
 | This activity promotes inquisitiveness in pupils about a butterfly through singing, video, picture cards, eBook, encyclopaedia and others. |
|  | * 1. Expanding kids’ natural interest
 | An activity to expand pupils’ natural interest about a butterfly. For example, investigating the natural life cycle of a butterfly in a butterfly farm.  |
|  | * 1. Encouraging and appreciating students’ questions
 | An activity to encourage pupils to ask questions, seek for answers and solutions to the problems.  |
|  | * 1. Inviting STEAM Experts
 | An activity conducted with the experts who may share information and experience related to the researched topic in STEAM teaching. |
|  | * 1. Creating meaningful atmosphere
 | An in-depth scientific investigation on butterflies with guidance from the experts and teachers. For instance, investigating the use of magnet in moving the butterfly model. |
| 1. STEAM in the future
 | * 1. Current STEAM Perspective
 | An activity to recognize pupils’ knowledge to solve problems. For example, the limited space for butterflies to reproduce in the urban area.  |
|  | * 1. STEAM Technology Inventor
 | An activity to make pupils a creative inventor of STEAM Technology. For instance, making a butterfly cage.  |
|  | * 1. Presenting STEAM Technology Work
 | An activity to encourage pupils to communicate and deliver information based on their own experiences as they become STEAM Technology inventor.  |

**Table 1.1** *Fred Rogers’* STEAM

1. **RESEARCH METHOD**

This research was conducted aiming at exploring experts’ perceptions of Fred Rogers’ approach as an appropriate STEAM teaching strategy in preschools. It involved four experts as the research informants. Two of the experts were servising in the field of STEAM Education in Institute of Teacher Education, Malaysia. The third expert was from Curriculum Development Department, Ministry Of Education Malaysia and the fourth one was from a local university. Both the third and the fourth experts were identified to have expertise in the field of preschool education. All the experts were selected purposively as the selection was made based on their expertise in STEAM Education, particularly at the preschool level. The details of the experts are summarised in Table 1.2.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No** | **Position** | **Gender** | **Field** | **Place of service** | **Experience** |
| 1 | Lecturer | Female | STEAM Education | Institute of Teacher Education, Malaysia  | 23 years |
| 2 | Lecturer | Male | STEAM Education | Institute of Teacher Education, Malaysia  | 23 years |
| 3 | Curriculum maker | Male | Preschool Education | Curriculum Development Department, MOE  | 13 years |
| 4 | Lecturer | Female | Preschool Education | Local university | 27 years |

**Table 2.1** Details of Experts

The data were collected through semi structured interviews (which took approximately two hours for each expert). The researcher developed a set of instrument on Experts’ Needs Analysis which had been earlier adapted from Needs Analysis Instrument by Muhammad Nidzam Yaakob (2017) to be used throughout the interview sessions. The details of the data collection execution are as seen in Table 2.2.

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Date of interview**  | **Time of interview** | **Place of interview** |
| Expert 1 | 05 July 2018 | 09.00 a.m.– 11.00 a.m. | IPG Teknik Kampus Bandar Enstek Nilai Negeri Sembilan |
| Expert 2 | 05 July 2018 | 02.30 p.m. – 04.30 p.m. | IPG Teknik Kampus Bandar Enstek Nilai Negeri Sembilan |
| Expert 3 | 14 May 2018 | 02.00 p.m. – 04.00 p.m. | Curriculum Development Department, MOE |
| Expert 4 | 08 May 2018 | 11.30 a.m. – 01.30 p.m. | Universiti Pendidikan Sultan Idris |

**Table 2.2** Executions of Expert Interviews

The qualitative data obtained from the interviews was analysed thematically in line with the research question ‘To what extent Fred Rogers’ Approach is appropriate for preschool STEAM teaching?’ The data were first transcribed, recorded and was later reduced in order to answer the research questions. The process of data reduction included selecting, focusing, simplifying and transforming the obtained data from the transcript. After the reduction process, the researcher extracted the needed data and made conclusions as well as verification (Miles et al. 1994). Verifying the data is very essential in ensuring their quality as the researcher attempted to meet the objective of the study.

1. **RESULTS AND DISCUSSION**

The research findings were discovered to answer the research question. The discussion of the findings highlights that all experts agreed and stated that Fred Rogers’ approach is an appropriate STEAM teaching strategy in preschools. This is because this approach pays attention to the teaching practice for kids ranging from five to six years old.

*“In my opinion, I strongly agree with the usage of this approach...*

*This approach is seen appropriate as it focuses on kids aged five and six..that is for preschool stage..”*

(Expert 1, lines 136-141, 05/07/2018)

*“In my opinion, this approach is appropriate...”*

(Expert 2, lines 98, 05/07/2018)

*“Overall, Fred Rogers’ approach is appropriate to use.”*

(Expert 3, lines 138-140, 14/05/2018)

*“In my opinion, this approach is very appropriate to use”*

(Expert 4, lines 89-90, 08/05/2018)

From the discussion with Expert 1, the approach is appropriate as it is seen to be parallel to kids’ inquisitive characteristics which love to ask, seeking for reasons and consequences of certain physical changes and have the initiatives to creatively find the solutions to the problem. Besides, this approach fulfills the basic needs of those kids who love to actively explore and investigate any situations that take place around them. This result was obtained from the interview with Expert 1:

*“this approach is very relevant to the characteristics and needs of preschool students who love to make inquiries...*

*Love to find out why..reasons and consequences of a situation..and seek for various solutions without feeling bored...”*

 (Expert 1, lines 145-151, 05/07/2018)

Expert 2 was in a positive opinion of Fred Rogers’ approach for STEAM teaching activity. It is appropriate to be used by preschool teachers. This is because the approach applies inquiry-based learning that teaches kids to be effective constructor of STEAM knowledge and skills. Adding to that, inquiry-based learning is one of the teaching strategies that is recommended in the National Preschools Standard Curriculum (KPM, 2016c). This inquiry-based learning allows students to naturally improve students’ knowledge and skills of STEAM. This finding is as based on the interview with Expert 2:

*“because it takes into account the learning that is based on inquiry...therefore it can effectively expose kids to construct knowledge and skills related to STEAM.”*

(Expert 2, lines 100-104, 05/07/2018)

Similarly, Expert 3 believed in the importance of applying this approach by teachers as STEAM teaching has been designed to equip students with knowledge, skills and values. The expert also recommended that this approach be executed holistically by teachers comprising three main activities which are designed to complement each other. Activities like conversation, scientific investigation and project are in line with the features of STEAM which are to construct knowledge and understanding of certain topics through investigations and explorations. This finding is as obtained from the interview with Expert 3:

*“This is because its process comprises intended knowledge, skills and values which are to be mastered by students.*

*The three main steps highlighted may allow students to master STEAM beginning from early stage of school.*

*To ensure students’ ability in mastering STEAM elements, the approach used must be holistic according to the recommended phase. Suggested activities like conversation, scientific investigation and project fulfill STEAM features.”*

(Expert 3, lines 142-153, 14/05/2018)

The findings obtained from Expert 4 indicate that Fred Rogers’ approach is in line with STEAM learning concepts which are based on inquiring and investigating activities. Therefore, this approach could positively expand students’ knowledge and understanding through learning-by-doing activities or self investigation. This recommendation is reported as based on what has been shared by Expert 4:

*“it is in line with the STEAM concept itself that its activities are based on questioning and investigating.*

*This may expose the kids to experiencing constructing their knowledge and undertsanding through “learning by” doing activities, through self investigation.”*

(Expert 4, lines 90-96, 08/05/2018)

1. **CONCLUSION**

Having reviewed the interview findings from all the four experts helps the researcher to answer the research question. It can be concluded that all experts agreed that Fred Rogers’ approach serves as an appropriate STEAM teaching strategy to be practiced by teachers in preschools. These experts supported that this approach meets the features and fulfill the needs of STEAM Education at preschool level. This is because STEAM concepts are learnt by kids through inquiring and investigating certain phenomena related to their everyday life. Hence, Fred Rogers (2003) stresses that the actual STEAM skills are mastered when kids become confident to inquire about anything and find out the solutions to any problems faced.

The uniqueness of this approach has convinced the experts that STEAM be practiced by teachers through inquiry based learning and learning-by-doing activities among preschool students. Fred (2003) starts his teaching with the kids by inquiring certain topic or theme, followed by meeting the experts, video screening or sharing his experience visiting the kids to help them explore a topic in depth. According to Fred (2003), teachers also need to focus on the tools used with the students besides paying attention to what they ought to learn. Kids are believed to be genuine STEAM investigator who commit in terms of effort, feeling and experience towards the learning (Fred Rogers, 2003). Therefore, teachers’ authenticity and care are essential in ensuring the success in generating future innovators.

All considerations are translated by Fred (Sharapan, 2012) in his teaching through activities like conversation, scientific investigation and projects which are integrated in a STEAM teaching process. The execution of STEAM teaching which is begun with STEAM Language Conversation allows space for kids to easily get the exposure towards STEAM concepts. The teaching is expanded through STEAM investigation in a real world. The use of materials and technological tools are exposed optimally in order to create a meaningful learning ambience for kids. The last step requires students to be involved in a STEAM project. STEAM Project is a reinforcement activity related to STEAM knowledge which has been earlier obtained in steps one and two.

 On the whole, experts collectively believed that this approach prioritises certain aspects like age, features, basic needs and abilities of kids for each activity implementation. Experts also agreed that Fred Rogers’ STEAM has been developed based on practices which are appropriate with kids’ development. This enables knowledge, values and skills to be instilled in students effectively.

**REFERENCES**

Bahagian Pembangunan Kurikulum KPM. (2016). *Kurikulum Standard Preschools Kebangsaan Semakan 2017.* Putrajaya. Kementerian Pendidikan Malaysia

DeJarnette, N.K.,.(2018). Implementing STEAM in the early childhood classroom.

 *European Journal of STEM Education*, 3(3), 18. https://doi.org/10.20897/ejsteme/3878

Edwards, L. C. (2006). *The creative arts: A process approach for teachers and children*, (4th ed.). Columbus, OH: Merrill.

Gordon, A. M., & Browne, K. W. (2011). *Beginnings and beyond: Foundations in early childhood education* [e-book]. Retrieved from <https://epdf.pub/queue/beginnings-amp-beyond-foundations-in-early-childhood-education-eighth-edition.html>

Gunn, J. (2018, November 7). The art of inquiry in STEAM education. Retrieved from <https://education.cu-portland.edu/blog/classroom-resources/steam-inquiry-based-learning/>

Jamil, F. M., Linder, S. M. and Stegelin, D. A. (2018). Early childhood teacher beliefs about STEAM education after a professional development conference. *Early Childhood Education Journal*, 46(4), 409-417. <https://doi.org/10.1007/s10643-017-0875-5>

Karen W. Lindeman Michael Jabot Mira T. Berkley. (2014). The Role of STEM (or STEAM) in the Early Childhood Setting: inlearning across the Early Childhood Curriculum*. Learning Across the Early Childhood Curriculum Advances in Early Education and Day Care*, 17, 95-114. Retrieved from

[http://dx.doi.org/10.1108/S0270-4021(2013)0000017009](http://dx.doi.org/10.1108/S0270-4021%282013%290000017009)

Kang, M., Park, Y., Kim, J., & Kim, Y. (2012). Learning outcomes of the teacher training program for STEAM education. International Conference for Media in Education, Beijing.

Katz, L. (2010). STEM in the early years. *SEED Paper for Early Childhood*

*Research and Practice, 3*(1), 1–3.

Kim, Y., & Park, N. (2012a). Development and application of STEAM teaching model based on the Rube Goldberg’s invention. *In Computer science and its applications* (pp. 693–698). The Netherlands: Springer.

Miles, M. B. &Huberman, A. M. (1994). *Qualitative data analysis*. 2nd ed. Thousand

Oks: Sage.

Miller, J., & Knezek, G. (2013). STEAM for student engagement. In R. McBride & M. Searson (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2013 (pp. 3288–3298). Chesapeake, VA: Association for the Advancement of Computing in Education (AACE)*. Retrieved from <http://www.learntechlib.org/p/48602>

Muhammad NidzamYaakob. (2017). *Reka bentuk model kurikulum m-pembelajaran pengajian profesional di Institut Pendidikan Teachers* (Tesis Phd). Universiti Utara Malaysia, Kedah.

Quigley, C. F., &Herro, D. (2016). “Finding the joy in the unknown”: Implementation of STEAM teaching practices in middle school science and math classrooms. *Journal of Science Education and Technology*, 1-17.

Piro, J. M. (2010). Going from STEM to STEAM: The arts have a role in America’s future too. *Education Week*, 29(24), 28–29.

Robelen, E. W. (2011). Building STEAM: Blending the arts with STEM subjects. *Education Week*, 31(13), 8. Retrieved from <http://ezproxy.rowan.edu/login?url=http://search.proquest.com/docview/910218761?accountid=13605>

Rogers, F. (2003). The world according to Mr. Rogers: Important things to remember. New York, NY: Hyperion.

Schirrmacher, R. (2002). *Art and creative development for young children*. Clifton Park, NY: Thomson Delmar Learning.

Sharapan, H. (2012). From STEM to STEAM: how early children educators can apply Fred Rogers’ Approach. *Young Children. 67*(1), 36–40. Retrieved from <https://www.bowdoin.edu/childrenscenter/pdf/FromSTEMtoSTEAM_FredRogersApproach_YoungChildren2012.pdf>

Sousa, David A &Pilecki, T.(2013). *From STEM to STEAM: using brain-compatible strategies to integrate the arts.* United Stated. SAGE Publication Ltd.

Sullivan, A., Strawhacher, A., &Bers, M.U.(2017). Andcing, drawing, and dramatic robots: integrating robotics and the arts to teach foundational STEAM concepts to young

children. *Robotics in STEM Education*. doi 10.1007/978-3-319-57786-9\_10

Suraya, Norsalawati& Nasir. (2017). Integration of STEM education in Malaysia and why to STEAM. *International Journal of Academic Research in Business and Social Sciences.* Advance online publication. doi: 10.6007/IJARBSS/v7-i6/3027

Tarnoff, J. (2010). STEM to STEAM: Recognizing the value of creative skills in the competitive debate. *Huffington Post*. Retrieved from

<http://www.huffingtonpost.com/john-tarnoff/> stem-to-steam-recognizing\_b\_756519.html

Unit Pelaksanaan and Prestasi (2017). Pelan pembangunan pendidikan Malaysia 2013-2025: laporan tahunan 2017, Putrajaya: Kementerian Pendidikan Malaysia

Van Meeteren, B., & Zan, B. (2010). Revealing the work of young engineers in early childhood education. *Early Childhood Research and Practice*. Collected Papers from the SEED (STEM in Early Education and Development) Conference. Retrieved from http:// ecrp.uiuc.edu/beyond/seed/zan.html

Wynn, T.,& Harris, J., (2012). Toward a Stem + Arts curriculum: Creating the teacher team. *Journal Art Education*. 65(5), 42-47. https://[doi.org/10.1080/00043125.2012.11519191](https://doi.org/10.1080/00043125.2012.11519191)

Yakman, G (2010, July 8). 2006-2010 What is STEAM: short overview paper. Retrieved from <https://steamedu.com/downloads-and-resources/>

Yakman, G., & Lee, H. (2012). Exploring the exemplary STEAM education in the US as a practical educational framework for Korea. *Journal of Korea Association Science Education*, *32*(6),1072-1086.