Elementary school teachers’ perceptions of STEM: What do teachers perceive?

P A Laksmiwati, R S Padmi and U Salmah
SEAMEO Regional Centre for QITEP in Mathematics, Yogyakarta, Indonesia

E-mail: pasttitalaks@gmail.com

Abstract. At the moment, educational issues are developing and rapidly increasing. One of the examples is the integration of Science, Technology, Engineering, and Mathematics called STEM. In Indonesia, STEM is a relatively new concept that is booming with potential. In the mathematics classroom, teachers have to facilitate students exploring STEM activities in the learning process. In response to this, SEAMEO Regional Centre for QITEP in Mathematics has embarked its programme through training and research. This paper reports on a study that investigated what teachers perceive about STEM Education which can support STEM education practices. Moreover, this article explains integrative nature of STEM activities provided. The STEM activities designed are related to the concept of resilience in bungee jump (Science) and proportional relationships between quantities (Mathematics). A survey method has been chosen in this study and data were collected using Likert-scale questionnaires and interviews. The results of this study provide an understanding of teachers’ perceptions of STEM which includes teachers’ pedagogical needs and teachers’ readiness in the STEM implementation. These findings suggest that teachers have positive perceptions on the STEM integration in the mathematics learning. There are some recommendations that intensively STEM trainings for teachers, learning resources in the STEM integration, pedagogical supports from Indonesia Ministry of Education, and textbooks that provide STEM-related projects are needed.

1. Introduction
In this 21st-century era, skills which more than content knowledge are needed in order to be successful. Competition is a fact that must be faced by people in this era. Either to be survived or succeed, a series of high or higher-order skills and abilities have been identified as crucial. The skills usually called 21st-century skills which include creativity, critical thinking, collaboration, and communication [1]. It is believed that the skills can contribute on giving positive impacts on the individual life skills. STEM education is believed as a huge movement in educational innovations and gained impressive attentions [2]. STEM education provides a good opportunity to stimulate students to become better problem solvers, innovators, and creators ([3]; [4]) and influences their future, especially on the 21st-century workplace ([5]; [6]). Thus, it is important that STEM has to be integrated in mathematics classroom. In this article, teachers’ responses to a set of STEM activities that integrated in mathematics classroom in designing and constructing a bungee jump. The activity is adapted from California State University Long Beach. Teachers’ knowledge and belief in STEM integration remains a challenge because influencing how they perceive of STEM education. Thus, teachers’ training remains important in order to bring positive impacts of STEM.
2. STEM integration

2.1. Perspectives on STEM Integration

STEM stands for Science, Technology, Engineering, and Mathematics and it was originally called SMET ([7]). As an integrated learning, STEM becomes a good idea to facilitate students in learning science, technology, engineering, and mathematics. It is suggested that a real-world situation is used in the STEM implementation and designed as investigations using engineering design process ([8]).

Moreover, there are several benefits of STEM integration, for example improving students’ interest, learning performance which includes problem solving skills, critical thinking, and creativity ([6]; [3]; [7]). Regarding those benefits and gaining them, teachers need to understand STEM education and how to implement it in the classroom. There are seven perspectives of STEM integration in the classroom ([9]). First, the perspective of silos and post holes, every subject of S, T, E, M is placed as separate disciplines (Figure 1a). Second, STEM is illustrated as a house with separate rooms that are used when needed. For example, when science incorporating the other three subjects in the teaching and learning process (Figure 1b). Third, STEM integration is called as a shopping centre with department stores and specialty shops (Figure 1b). This perspective represents that science and mathematics are connected by technology or engineering. The fourth perspective describes STEM as coordination of resources among building sub-contractors, as shown in the Figure 1d. Then, in the fifth perspective, STEM is illustrated as a process which includes a creation of a new product by combining other subjects (S+ M = as a part of STEM activities) and can be shown in Figure 1e. The sixth perspective of STEM called as a manufacture which has overlapping problems and investigations among those subjects in the appropriate problems (Figure 1f). The last and become the most ideal perspective, STEM is illustrated as string quartet playing and called transdisciplinary sustainable society course (Figure 1g).

Figure 1. The seven perspectives of STEM education
In the classroom, the perspectives above are the way of teachers to implement STEM Education. Even though there is an integrated model of STEM called transdisciplinary, STEM cannot be integrated as a subject learning considering that the idea will be very difficult because not easy for the teacher to master in every content knowledge and will give negative impact on the students ([10]; [11]).

2.2. Engineering design process in STEM activities
In the implementation of STEM, Engineering Design Process (EDP) becomes very significant in the development of students’ thinking and problem solving in STEM activities. Engineering design process is defined by an investigation process which consists of standardized process and begin with open-ended problem identifying and finishing with an ideal design ([12]). In the implementation, EDP is related to engineer characteristics, for example knowledge, creativity, brainstorm courage, the ability to accept unusual solution, communication skills, self-confidence, the feeling for a nice, the speed of the thought process, observing skill and etc ([13]) and some of these characteristics are included in 21st century skills. The EDP processes is illustrated by the following figure ([14]).

![Engineering design process](image)

**Figure 2.** Engineering design process

2.3. Teachers’ perception on STEM: What do teacher perceive about STEM?
Several studies of teachers’ and students’ perceptions of STEM had been conducted considering the importance of STEM ([15]; [16]). Teachers’ perception on STEM can be defined as teachers’ interpretation and judgment, as well as what they recognize of and expect from STEM ([17]). The followings are the indicators of teachers’ perception ([18]; [19]; [20]).

- **interpretation** refers to teachers’ understanding of STEM and how teachers teach STEM as a learning approach.
- **recognition**, refers to teachers’ acknowledgment and attention of STEM as a learning approach.
- **judgement**, refers to opinion regarding the value or relevance of STEM and decisions in accordance to those opinions.
- **expectation**, refers to what teachers expect of implementing STEM in their classroom.

Thus, this study wants to know how STEM education is valued, believed, or perceived by the teacher. To understand what is teachers’ perceptions of STEM education and why it is important to conduct a study of teachers’ perception of STEM education was the main purpose of this study.
3. Method
This activity was implemented over a day session of 4 hours and designed to give initial experience of STEM activities. This research aims to investigate teachers’ perceptions of STEM education and a survey method has been implemented. There are two research questions that guide this study are as follows:

- What do teachers perceive about STEM Education?
- What are the teachers’ pedagogical needs and readiness that support STEM education practices?

Thirty teachers participated in this study, who are elementary mathematics teachers. Data collection methods used in this research are questionnaire and interview. The questionnaire using the Likert scale, from 1 (strongly disagree) to 5 (strongly agree). There are forty items, a survey method is chosen in this study, thus the data collected were analysed. Furthermore, the interview was conducted to answer second research questions. They were asked about the following questions were asked of participants:

- What do you know about STEM education?
- Do you feel prepared for the implementation of STEM learning in your classroom or school?
- What are your difficulties during the implementation of STEM education?
- What kind of support do you need to implement STEM education?

4. Results and discussion

4.1. Bungee jumping activity
In order to give teachers experiences about STEM activities, this activity was designed to facilitate teachers to explore STEM through a bungee jump. The activity consists of exploration and constructing a model of bungee jump using rubber bands. In the main activity, discovering and measuring the falling distance of the doll, and then relates the increasing numbers of rubber bands with the distance. In the main activity was dealing with collecting data and creating a scatter plot from the data. The activity is related to Science (the concept of resilience in bungee jump), Engineering (developing and using models of bungee jump), Mathematics (interpreting the unit rate as the slope of the graph, and represent data on two quantitative variables on a scatter plot). The learning objectives are determining the relationship of the number of rubber bands and the falling distance by using the linear equation and predicting the number of rubber bands needed from a given falling distance and height.

**Preliminary Activities.** The activities began with the discussion of how to construct a bungee jump which includes the following main points:

a. The important factors of a bungee jump related to the height of the jumping, jumper’s weight, the safety, and the rope’s resilience.

b. The criteria which influences a bungee jump design to be more or less fun.

c. How to predict the number of rubber band based on a given distance of fall by using the line equation.

**Main activities.** In the main activity, they did several trials to construct a bungee jump and to measure the distance their doll falls. While constructing a bungee jump from various number of rubber bands how to tie the rubber bands with double loops, how to add the other additional rubber band were discussed, and how to measure the falling distance. The following figure is the illustration. Then, giving them chance to collect the data and plotting on the scatter plot. After collecting and plotting, they discussed the line of best fit and describe the relationship between the numbers of rubber band
and the falling distance which mean creating predictions based on the equation results and then discuss which equation was the best fit.

**Figure 3.** The tying result using double loops and measuring the falling distance

In fact, there were several methods to find out the line of best fit equation. Therefore, it was given a challenge to use more than a method. The following figure is the example of working result and the graph of data.

**Figure 4.** The result of discussion
Then, they discussed about the following points:

- The relationship between the number of rubber bands and the falling height.
- The equation for the line of best fit.
- How to predict the number of rubber bands needed for a given height?
- What should you do if the prediction results a decimal number?

At the end of the lesson, the participants were given chance to present their discussion results.

### 4.2. Teachers perception on STEM

To address the research questions, a questionnaire has been used in this research. How teacher perceives about STEM education is discussed in the following passage. From Table 1 and Table 2 below the result indicated that teachers have positive perception of STEM education in their interpretation, recognition, judgement, and expectation. The mode scores have high responses and imply that teachers have positive perception on STEM education. Based on the questionnaire items, teachers have a good enough pedagogical knowledge and awareness about the advantages of STEM education. For example, in item 1, 5, 9, and 13 which are related to their interpretation of STEM as an interdisciplinary learning approach, as an educational program or curriculum, and incorporates material from various disciplines. Then, the teachers also aware that making STEM as a school subject is not a good idea. Instead of teachers’ awareness and motivation of STEM implementation achieved a high score, but their belief about STEM education practices has a lowest score for all aspects.

#### Table 1. Teachers’ perceptions mean score for interpretation and recognition aspects

| Aspects in teachers’ perception | Item Number | Mode Score | Criteria       |
|---------------------------------|-------------|------------|----------------|
| Interpretation                  | Item 1      | 5          | Strongly Agree |
|                                 | Item 5, 9, 13, 21, 25, 29, and 33 | 4          | Agree          |
|                                 | Item 17     | 3          | Neutral        |
| Recognition                     | Item 2, 6, 14, 30, and 34 | 4          | Agree          |
|                                 | Item 10     | 3          | Neutral        |
|                                 | Item 18, 22, 26, and 38 | 2          | Disagree       |

#### Table 2. Teachers’ perceptions mean score for judgement and expectation aspects

| Aspects in teachers’ perception | Item Number | Mode Score | Criteria         |
|---------------------------------|-------------|------------|------------------|
| Judgement                       | Item 3, 7, 15, 23, 27, 35, and 37 | 4          | Agree            |
|                                 | Item 11, 21, and 39 | 2          | Disagree         |
|                                 | Item 19     | 1          | Strongly Disagree|
| Expectation                     | Item 4, 8, 12, 16, 20, 24, 32, and 36 | 4          | Agree            |
|                                 | Item 28 and 40 | 2          | Disagree         |

Moreover, their perceptions of STEM in accordance of students’ learning which consists of how STEM education stimulating students to become better problem solvers, how STEM providing student-centred learning, how STEM increasing creativity and interest, and how STEM is important for their future because STEM education is critical for them to be able to compete globally (item 2, 27, 29, and 33). Move on the urgency of STEM in Indonesia, teachers agreed that STEM as the most talked topic in education is relevant to the current needs of their region and also Indonesia as
developing country, and of course mathematics curriculum in general (item 14, 18, 22, and 26). In addition, STEM education also perceived as an educational innovation which is fascinating, appealing, meaningful, exciting, and joyful (item 3, 7, 11, 15, and 19).

Despite STEM is relatively new for teachers, it can be shown from this study that they are ready to implement STEM in their mathematics classroom. They were motivated to implement STEM education in their classroom. In addition, they stated that feeling comfortable to implement STEM as a learning approach in mathematics classroom and ready to to implement. Among those teachers around 67% teachers felt motivated and will be ready to implement STEM in their classroom.

**Figure 5.** Teacher readiness in implementing STEM

Considering the positive teachers’ response on how they perceive STEM integration in mathematics teaching and learning. There was a crucial problem which appears, they agreed that applying STEM education in the classroom would be difficult due to lack of resources. The following picture shows that 43% teachers agreed and 7 % strongly agreed that it would be difficult to implement STEM due to lack of resources.

**Figure 6.** Teachers' perception on the STEM resources

From the interview results, all of the teachers who participated in this study have not implemented STEM education in their school yet. Most of them has not familiar with STEM education yet and being well-informed after completing the training. From the beginning, most of them familiar with STEM stands for science, technology, engineering, and mathematics. Regarding, the readiness most of the teacher were ready to implement STEM, but there argued about several difficulties because the students are not ready as well as the IT support facilities (e.g. laptop, OHP, computer, etc.). The other
difficulties are students’ low motivation, funding, industrial support, and time-consuming. Lastly, regarding the supports which are needed in the implementation in teaching and learning, teachers suggested that the government provides intensively STEM trainings for teachers, learning resources in the STEM integration, pedagogical supports from Indonesia Ministry of Education, and textbooks that provide STEM-related projects.

5. Conclusion
The results of this study provide an understanding of teachers’ perceptions of STEM which includes teachers’ pedagogical needs and teachers’ readiness in the STEM implementation. Returning to the findings and discussion, it is now possible to state that teachers have positive perception on the STEM integration in the mathematics learning. It was also shown that there are positive interest and motivation from teachers to implement STEM in their learning. There are some recommendations that intensively STEM trainings for teachers, learning resources in the STEM integration, pedagogical supports from Indonesia Ministry of Education, and textbooks that provide STEM-related projects are needed.

There were several limitations of this study which involved the size of the sample, limited time of implementation and discussion. These findings also highlight the need for further collaboration among STEM-related subjects’ teachers to design a good lesson together.

References
[1] Helen B and Rhona S 2013 Rethinking pedagogy for a digital age: Designing for 21st century learning (New York: Routledge)
[2] Melanie L, Elizabeth N, Heather K, Jeanne C, Courtney B, Sandra H, Ahmed I, and Stephanie L 2016 The eight essential elements of inclusive STEM high schools Int. J. of STEM Education 3 21.
[3] Janice S M 2006 Attributes of STEM education (Baltimore: Teaching Institute for Essential Science)
[4] Cristine R 2016 Translating STEM education research into practice (Camberwell: Australian Council for Educational Research)
[5] Mary M C, Jennifer G W, Matthew J E, and Robert M C 2010. A companion to interdisciplinary: STEM project-based learning (Texas: Sense)
[6] Micah S, Tamara J M, and Gillian H R 2012 Considerations for teaching integrated STEM education J. of Pre-College Engineering Education Research 2 4.
[7] David W W 2014 What is STEM education and why is it important Florida Association of Teacher Ed. J. 1 1
[8] Todd R K and Geoff K 2016 A conceptual framework for integrated STEM education Int. J. of STEM Education 3 1
[9] Gillian K 2017 Inquiry-based practices for the teaching of STEM: Teacher STEM literacy for transdisciplinary teaching Proc. Int. Conf CoSMed 1
[10] Mark S 2009 STEM, STEM education. STEMmania. The Technology Teacher 68 20
[11] Paraic T and John O 2014 Authentic integration: A model for integrating mathematics and science in the classroom Int. J. of Mathematical Education in Science and Technology 45 703
[12] Jeffrey C L and Filippo A S 1999 Defining the engine design process J. of Engineering Design 10 109
[13] Milan R and Sinisa K 2017 Aspects of the engineering design process Proc. Int. Conf Scientific Conference on INDUSTRIAL SYSTEMS 344
[14] Roxanne M 2016 The engineering design log: A digital design journal facilitating learning and assessment Proc. Int. Conf SEE Annual Conference & Exposition 26153
[15] Hebb E and Nasser M 2015 Science teachers’ perceptions of STEM education: Possibilities and challenges. Int. J. of Learning and Teaching 1 51
[16] Chew C M, Idris N, Leong K E, and Daud M F 2013 Secondary school assessment practices in science, technology and mathematics (STEM) related subjects *J. of Mathematics Education* 6 58

[17] Larry N, Darcia N, and Tobias K 2008 *Handbook of moral and character education* (New York: Routledge)

[18] Victoria L B 2008 *Assessing perceptions using education for the future questionnaires* (California: Education for the Future)

[19] Robert S 2006 *Educational psychology: Theory and practice* (Boston: Pearson)

[20] Dale H S. (2012). *Learning theories an educational perspective* (Boston: Pearson)