STEM learning content in elementary school national curriculum

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Abstract. STEM education implementation in Indonesia particularly in elementary level is still weakly established although it should have its own place in the development of the required 21st century skills. Therefore, this study aimed to identify curriculum content which intercept with STEM subjects as well as teachers’ understanding about STEM and its potential integration in elementary curriculum. This study deploys qualitative explanatory method. Data collection was done by the use of form to help analyse curriculum contents which potentially joint STEM subjects both in the Core Standards and thematic text books of grades K4-K6. Online questionnaire is used to gather data about teachers’ knowledge of STEM and its potential in the curriculum practice. Results indicated that national curriculum strongly supports the enhancement of STEM education in upper elementary school level. Yet, almost all teachers were not familiar with STEM, its importance, nor how it is implemented in classroom learning. So, teachers require further professional development to improve their competences in designing and implementing STEM learning according to national curriculum standards in classroom level.

1. Introduction

21st century workforce demands scientifically-technology literate global citizens who are competent in solving complicated daily issues in the frame of mathematics, science, technology, as well as engineering process design. Previous studies revealed that integrating science with technology and math in the simple process design tasks for students strongly supports the development of scientific literacy [1]. In accordance with this, it is believed that scientifically literate citizens have adequate knowledge about the nature of science [2,3]. This proposed argument views nature of science is interrelated with process, values, and beliefs inherent to the development of scientific knowledge and technology development [4,5]. Technology innovations and inventions are also intertwined outcomes of scientific knowledge applications and vice versa [1]. This foundation lays STEM education as the root in recent global education reforms.

Developed countries such as the US [6] and Australia [7] have broadly implemented STEM education in their practice in various levels, starting from early childhood to higher education. Similar trend sounds in Indonesia neighbouring countries. STEM education in developing countries in South East Asia region is established under the coordination of South East Asia Minister of Education (SEAMEO) QITEP in Science Council [8]. The development of STEM education in Indonesia has
become an interesting area of study in recent years [1,9]. Yet, its implementation in all levels of education has not been established.

Previous studies revealed that teachers held a limited understanding about STEM. Teachers generally view STEM as a learning strategy [10,11]. The situation is essentially critical in STEM education practice, particularly in the foundational stage of education. Another consideration about the difficulties in STEM education is the relevancy with the National Curriculum. So there is a need to study these two aspects prior to further development of STEM in elementary level practice.

1.1. Research questions
Problem in this study was organized into two research questions as follows.
   a. What do teachers understand about STEM education?
   b. Is Elementary School National Curriculum strongly support the integration of STEM learning in its implementation?

1.2. Research goals
According to the research problem mentioned previously, this study targeted to:
   a. Investigate teachers’ understanding about STEM education.
   b. Identify whether Elementary School National Curriculum support the development of STEM learning in its classroom practice.

2. Methods
This study is a part of a bigger R & D research in the development of STEM learning materials for elementary school. This first part of the R and D deployed a qualitative explanatory method to establish a strong reference point to develop supplementary learning materials that correspond with K4-K6 core competencies mentioned in the national curriculum.

2.1. Population and participants
Population of this qualitative study was 250 elementary teachers teaching grades K4-K6 in schools with A and B-accreditation grade in Bandung, West Java. 25 teachers from 6 elementary schools were involved as respondents. These teachers have taught for at least 2 years. Teachers aged range from 25-40 y.o. Teachers’ academic background is relevant with elementary education and graduated from acknowledged universities in Indonesia. 3 teachers hold Master Degree in Elementary Education and the rest of the participants hold Undergraduate Degree in the same field.

2.2. Data collection and instrumentation
Data about teachers’ understanding about STEM education was gathered through a survey involving 25 teachers by the use of online questionnaire tool with the aid of Google form. Survey was carried out in the first semester of 2018/2019 academic year. Practical issue was the reason for using an online questionnaire. Questionnaire form was adopted from Pimthong and William [9] and covered indicators of STEM definition, its importance in elementary education, and how STEM is integrated in the curriculum design and implementation. The questionnaire consisted of 10 open-ended questions. To ensure trustworthiness of the responses, the questionnaire form was collected anonymous.

Data related with curriculum content analysis which explored the opportunity of STEM learning implementation in elementary schools was gathered in table form to determine which core competencies of Math and Science National Standards were potential to be integrated within STEM. Data collection also involved resources in the form of K4-K6 2018 revised thematic teacher and student books.

2.3. Data analysis
Thematic content analysis was carried out to analyze teachers’ responses about STEM which fell into four themes, namely teachers’ knowledge about STEM and STEM education, STEM importance, STEM integration in the national curriculum, and the relationship between all four dimensions in STEM. The
results were then discussed to infer teachers’ understanding about STEM and its potential practices. The analysis results were then quantified in percentage to show the level of teachers’ understanding. Content analysis was also performed to analyze data from the table form. All core competencies in National Standards supporting STEM learning were then described correlatively along with the themes, subthemes, and lessons in each book. Results were then elaborated to arrange lesson activities in relevant themes. Descriptive statistic analysis technique was used to investigate percentage of competencies, themes, and subthemes which support STEM learning in each grade.

3. Results and discussion

3.1. Teachers’ understanding about STEM learning
Data about teachers’ understanding in STEM learning was described briefly as follows.

3.1.1. Teachers’ knowledge about STEM
Amongst 25 teachers who were delivered the questionnaire form, only 15 (60.0%) of them responded. Questions exploring teachers’ knowledge about STEM are showed in Table 1 along with the responses.

| No | Question                        | Responses                        |
|----|---------------------------------|----------------------------------|
| 1  | Have you heard about STEM?      | Yes, quite a lot (46.67%)        |
|    |                                 | Yes, once or sometimes (20.00%)  |
|    |                                 | Never (33.33%)                   |
| 2  | What does STEM stand for?       | Science, Technology, Engineering, Math (46.67%) |
|    |                                 | Other answer (20.00%)            |
|    |                                 | N/A (33.33%)                     |
| 3  | Where did you hear or know about STEM from? | Internet (46.67%) |
|    |                                 | Seminar and (or) lectures (13.33%) |
|    |                                 | Colleagues (13.33%)              |
|    |                                 | Prints (articles, journals, books) (6.67%) |
|    |                                 | N/A (26.67%)                     |
| 4  | What is STEM?                   | Incorrect (83.33%)               |
|    |                                 | Correct (13.33%)                 |
|    |                                 | N/A (33.33%)                     |

The table informed that less than half of participants knew about STEM which corresponds to prior research that elementary teachers held a limited knowledge about STEM although its issue sounds in nowadays global education [9]. Information about STEM mainly came from the internet, seminar, or colleagues. This evidence leads to the reason why STEM education is rarely taught in the elementary school programs. Responses to the fourth question, emphasized empirical data about the lacking knowledge definition of STEM, e.g: “STEM is Science learning that used technology”. Only 2 teachers responded correctly, like: “STEM is a learning combines mathematics and science with technology”.

3.1.2. Teachers’ understanding about the importance of STEM learning
Responses in Table 2 illustrated that almost all teachers failed to identify how essential STEM is in elementary education. Only 1 teacher expressed moderate knowledge by mentioning that “STEM purpose is to stimulate students to think critically, logically, and creatively to compete in the global era”. This goes in line with the idea of STEM education to prepare global citizens with required higher order thinking skills as well as engineering skills to compete in the 21st century workforce [9,11].

Answers to questions 6 and 7 confused with previous findings. 60.0% respondents expressed that STEM was important while 5 participants did not mention their ideas. The reasons of its importance were varied, such as “STEM is important because it can stimulate students who don’t like studying complicated subjects” and “It’s important because we live in sophisticated era”. Yet, there was also
relevant answer which reasoned that STEM enhanced students’ critical thinking ability which was in agreement with prior study results that STEM education helped teachers promote students’ 21st century skills that could all be useful for selecting careers in STEM workforce in the future [11].

### Table 2. Teachers’ responses about the importance of STEM learning.

| Item no | Question                              | Responses                       |
|---------|---------------------------------------|---------------------------------|
| 5       | What is the goals of STEM education?  | Correct response (6.67%)        |
|         |                                       | Incorrect responses (46.67%)     |
|         |                                       | N/A (46.67%)                    |
| 6       | Is STEM important in Students’ learning? | Yes, very important (66.67%) | Yes, quite important (60.00%) |
|         |                                       | N/A (33.33%)                    |
| 7       | Why is STEM important?                | Correct response (6.67%)        |
|         |                                       | Incorrect responses (73.33%)     |
|         |                                       | N/A (20.00%)                    |

#### 3.1.3. Teachers’ understanding about the integration of all dimensions of STEM

In the ninth questions participants were asked to draw a diagram to depict integration of all dimensions in STEM. But only 2 participants gave relevant responses without clear explanations about the Figure. From this limited evidence we can barely know if teachers acquired adequate knowledge about each aspect of STEM education and how they are organized in the learning practice.

The above proof indicated that STEM terminology is strange for the teachers. They might have heard about STEM yet they did not recognize its implementation. The fact confirmed the idea that if STEM education goes in advance beyond a slogan, teacher educators as well as teachers have to clarify what the acronym actually means for educational policies, programs, and practices [12].

![Figure 1](image.png)

**Figure 1.** Teachers’ illustration of the integration of STEM dimensions.

#### 3.1.4. Teachers’ understanding about the potential of STEM integration in the elementary school

### Table 3. Teachers’ understanding about the integration of STEM learning in the elementary school.

| Item no | Question | Responses |
|---------|----------|-----------|
| 8       | What outcomes can be obtained through learning that integrates STEM? | Correct response (6.67%) | Incorrect responses (46.67%) | N/A (46.67%) |
| 10      | Does the elementary school national curriculum support the implementation of STEM integration in the learning? | Yes (66.67%) | No (33.33%) | N/A (0) |

Inadequate understanding about STEM integration in classroom practice can be seen from teachers’ responses, e.g: “STEM might produce a game”. On the other side, 1 participant successfully suggested that STEM learning outcomes were the opportunity for students to exhibit their works, enhancing the skills of doing a simple research and develop scientific and Math literacy through project based learning. Nevertheless, answers to the last item contradicted with this finding. The responses obviously showed confusing ideas on how STEM is practised. Based on these conflicting results, member check was then
taken to ensure teachers’ ideas consistency. Surprisingly, teachers could not give brief explanation or examples of which themes and subthemes that were suitable with STEM projects. Only 1 participant mentioned that STEM could be integrated in grade 4 in several themes. Results indicated that most respondents have not analyzed the book content carefully and even most of them did not understand about STEM. This finding goes in line with prior research that proposed most teachers were lack of preparation to implement STEM practices that led to the limited numbers of interdisciplinary teaching and learning across STEM subjects [13,14].

3.2. STEM learning potential in Elementary school National Curriculum content
Belows are mentioned the occurrence of both elementary school Math and Science core competencies, themes, subthemes and lessons that were potential to integrate STEM in its implementation.

Table 4. Percentage of core competencies in elementary Math and Science that supports STEM learning according to the National Standards.

| Grade | Number of core competencies | Number of core competencies that are potential to integrate STEM | Percentage |
|-------|-----------------------------|---------------------------------------------------------------|------------|
| Math  |                             |                                                               |            |
| K4    | 20                          | 24                                                           | 83.33%     |
| K5    | 16                          | 14                                                           | 87.5%      |
| K6    | 16                          | 16                                                           | 100.0%     |
| Science |                              |                                                               |            |
| K4    | 6                           | 16                                                           | 37.5%      |
| K5    | 18                          | 18                                                           | 100.0%     |
| K6    | 16                          | 14                                                           | 87.5%      |

According to Table 4, it was obvious that elementary school national curriculum strongly supports STEM integration in its classroom implementation.

Table 5. Themes and subthemes in elementary school books that support STEM learning.

| Grade | Themes | Subthemes |
|-------|--------|-----------|
| K4    | 2      | 1, 2, 3   |
|       | 5      | 1, 3      |
| K5    | 1      | 1, 2      |
|       | 2      | 1, 2, 3   |
|       | 3      | 1, 2      |
|       | 4      | 1, 2      |
|       | 5      | 1, 2, 3   |
|       | 8      | 3         |
|       | 9      | 3         |
| K6    | 1      | 1, 2, 3   |
|       | 2      | 2, 3      |
|       | 3      | 1, 2, 3   |
|       | 4      | 1, 2, 3   |
|       | 5      | 1, 2, 3   |
|       | 6      | 1, 2, 3   |
|       | 7      | 1, 2      |
|       | 8      | 1, 2, 3   |

Based on the tabel, we can say that curriculum content was potential to be integrated within STEM learning. Almost 100% of the subthemes in K4-K6 were suitable to develop STEM skills. Depth observation of core competencies even showed a great potential for the ICT and technology skills.
development during the practice [15], which can be in the form of projects design or a problem based situation [1,9,10,16].

4. Conclusion
According to the research results and discussion, it can be concluded that firstly, teachers in elementary level did not have ample understanding about STEM, its importance and its implementation in the classroom practice in accordance with national curriculum standards. Secondly, elementary school national curriculum strongly supports the integration of STEM learning in classroom practice.

The limitation of this study is that the content of the books sometimes irrelevant with the core competencies in the national standards. So, further investigations is needed to explore more relevant thematic books in order to establish supporting supplementary STEM learning materials. Moreover, there is a need to promote teachers’ understanding about STEM as well as their efficacy and pedagogic competencies in delivering STEM learning to students through PLC or other TPD programs.

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