

## Trends of science technology engineering mathematics (STEM)-based learning at elementary school in Indonesia

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**Abstract:** This research investigates the results of studies related to the implementation of Science Technology Engineering and Mathematics (STEM)-based learning at elementary schools in Indonesia. Using the Systematic Literature Review (SLR) with meta-synthesis model, this research selects research articles related to STEM-based learning at elementary school in Indonesia from google scholar and google site as sources for primary data and secondary data, respectively. After reviewed through inclusion and exclusion criteria evaluated by quality assessments, 15 scientific articles published within 2015 to 2020 are analysed. Findings show that many studies have great interest in developing STEM-based teaching and learning materials, while others focus on identifying the impact of STEM-based learning on various learning achievements such as creative thinking skills, critical thinking skills, basic questioning skills, and scientific literacy, and learning achievement in general.

**Keywords:** Systematic Literature Review (SLR), STEM, Elementary school.

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## **INTRODUCTION**

The era of globalization or the era of openness marks the beginning of the 21st century. One of the 21st century's challenges is the need for good quality human resources (HR) in facing the challenges of the global world. The government must provide human resources (HR) capable of producing superior generations and improving education can be the starting point. Various aspects in the field of education must be adapted to the changes in times. According to Wijaya, Sudjimat, & Nyoto (2016), education has a vital role in ensuring human resources learn the ability in using technology and information, working together, making innovation, and having the ability to face life's challenges or known as life skills.

Indonesian education is currently implementing a higher quality education following globalization in the 21st century through Kurikulum 2013. Kurikulum 2013 has been implemented and reviewed through various studies, and the results prove that this curriculum can improve service efficiency and effectiveness and develop learning innovations. One form of efficiency and effectiveness of implementing the 2013 curriculum is introducing various new learning models that can support education in the 21st century. Learning models that are in line with the development of the 21st century are Science, Technology, Engineering, and Mathematics (STEM)-based learning (Bybee, 2013). STEM education is an approach to learning that integrates more than two disciplines STEM as a whole (Becker & Park, 2011). Meanwhile, Avery & Reeve (2013) states that STEM is an integrative approach from several disciplines that help students acquire skills and knowledge in STEM areas.

Due to its importance in promoting 21<sup>st</sup>-century skills, research on STEM education is an essential theme at international scientific conferences and publications, especially in the educational scope. Indeed, it indicates the development of STEM education practices all over the world. Thus, as a developing country, Indonesia is also required to meet the demand for emerging STEM education (Suwarma & Kumano, 2014).

Within the last decades, research regarding the implementation of STEM education in Indonesia is increasing, which involves studies in elementary, secondary, high school and tertiary education levels. These studies are mainly focused on developing teaching and learning materials, assessments, or best practices of STEM lessons.

On the other hand, understanding research trends on STEM education is also essential to further develop STEM education policies and practices. However, previous research reviewed STEM education-related studies in Indonesia from a broad perspective (Khotimah et al., 2021). While some performed the analysis of the STEM education movement from junior high school or senior high school level teachers' and students' perspectives (Permanasari, 2021; Nugroho et al., 2019). None had specifically reviewed research on STEM learning at the elementary school level in Indonesia. Therefore, this study aims to provide an overview and insight into research findings on STEM learning in Indonesian elementary schools to be used as a reference for stakeholders, policymakers, teachers and researchers to develop better STEM education at the elementary school level.

## **METHODS**

### **Research Design**

This research uses the Systematic Literature Review (SLR) with a meta-synthesis model involving scientific articles related to STEM education at the elementary school level in

Indonesia. Referring to (Kitchenham, 2004), SLR is a research method for identifying, evaluating, and interpreting all relevant research results related to particular research questions, specific topics, or phenomena of concern.

To achieve the aims of this study, three Research Questions (RQ) are made based on the needs of the selected topic. RQs is needed to help to collect useful information relevant to the study. The research questions (RQ) include:

(RQ1) : What is the focus of study in research related to STEM learning in Indonesian elementary schools?

(RQ2) : How is STEM-based learning implemented in Indonesian Elementary Schools?

(RQ3) : What are the results of the research on STEM learning in Indonesian elementary schools?

## **Procedure**

In general, there are three stages in the SLR method, namely: planning, conducting, and reporting. In the planning stage, research questions are formulated, and a research protocol is developed. The research protocol comprises specific procedures regarding search process, selection of article based on inclusion and exclusion criteria and evaluation of data quality or quality assessment. The research protocol is then carried out during conducting stage. The last step is reporting, in which the researcher writes the results and findings of SLR research in the form of the journal article.

## **Data Collection**

Data obtained in this study is in form of scientific articles collected from <https://scholar.google.co.id/> site as the primary data source and <http://google.com> as the secondary data source. Prior to being used in the study, each article is evaluated against inclusion and exclusion criteria as follows:

(C1) Article must be published in between 2015-2020.

(C2) Article must be obtained from <https://scholar.google.co.id/> or <http://google.com>;

(C3) The content of article must be related to STEM learning in schools.

Furthermore, in ensuring its relevancy to the RQs, all articles fulfilling inclusion and exclusion criteria are evaluated through Quality Assessment (QA). There are three criteria to address:

(QA1) Was the article published in 2015-2020?

(QA2) Was the article contained information related to the STEM in elementary schools in Indonesia?

(QA3) Was the article contained information related to the implementation of STEM learning in elementary schools in Indonesia?

Each article was given a score below for each of the questions above.

Y (Yes): if the QA is addressed

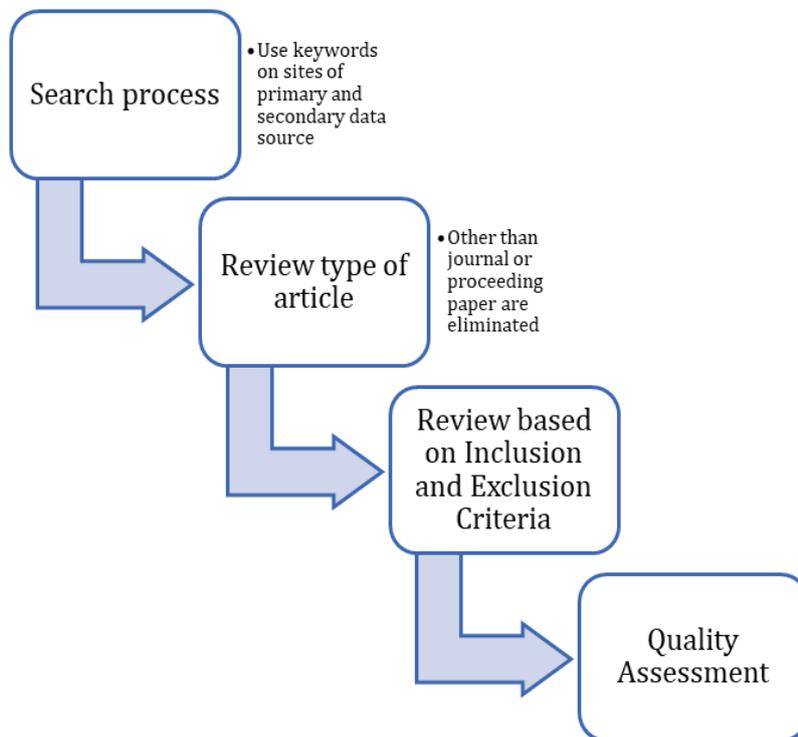
T (No): if the QA is not addressed

## Data Analysis

Data analysis techniques in qualitative research using the Systematic Literature Review (SLR) method consist of meta-analysis and meta-synthesis (Perry & Hammond, 2002). In this study, it was analysed using meta-synthesis techniques. Referring to Parry & Hammond (2002) meta-synthesis analysis technique is a technique for combining existing data to get new concepts or more profound understanding. The purpose of meta-synthesis analysis is to conclude much information to have good analytical power.

## RESULTS

The search process of article related to STEM learning in elementary school is used to answer all Research Question (RQ). The search process is carried out using a search engine (Google Chrome) with the site address <https://scholar.google.co.id/> (primary data) and <http://google.com> (secondary data). The keywords used in this search process are 'pembelajaran', 'STEM', and 'sekolah dasar'. Articles other than journal article or proceeding paper and published earlier than 2015 are eliminated. In general, the selection of articles as the data for this research is presented on the flow chart below.



**FIGURE 1.** Flowchart of articles selection

The results of the search process in primary and secondary data sources are evaluated using inclusion and exclusion criteria as mentioned earlier and the results can be seen in **Table 1**.

**TABLE 1.** Result of article selection based on inclusion and exclusion criteria

No	Author	Title	Study design	Year	C1	C2	C3	Decision
<b>Best Practices in STEM-based Learning</b>								
1	Mu'minah, I. H. Aripin, I.	<i>Implementation of Science Learning based ICT-Assisted STEM- to Improve 21st Century Skills (Implementasi Pembelajaran IPA Berbasis STEM Berbantuan ICT Untuk Meningkatkan Keterampilan Abad 21)</i>	Pre- experiment with one group Pretest-posttest	2019	√	√	X	X
2	Agustina, D., Kaniawati, I., & Suwarma, I. R.	<i>Application of STEM-Based Learning (Science, Technology, Engineering, and Mathematics) to Increase the Control of Variable Ability of Junior High School Students in Pascal Law (Penerapan Pembelajaran Berbasis STEM (Science, Technology, Engineering, and Mathematics) Untuk Meningkatkan Kemampuan Control of Variable Siswa SMP Pada Hukum Pascal)</i>	Quasi experiment with one group pre-test and post-test	2017	√	√	X	X
3	Amiruddin, B., Juwairiyah, A., & Subhan	STEM Education in Integrative Thematic Learning to Improve Students Creative Thinking Abilities in Elementary School	Quasi experiment	2019	√	√	√	√
4	Dewi, H. R.	<i>Improvement of Students' Creative Thinking Skills through the Application of STEM-Based Guided Inquiry (Peningkatan Keterampilan Berpikir Kreatif Siswa Melalui Penerapan Inquiry Terbimbing Berbasis STEM)</i>	Classroom Action Research	2017	√	√	X	X
5	Sumarni, W., Wijayanti, N., & Supanti, S.	<i>Students' cognitive abilities and creative thinking through project-based learning with a STEM approach (Kemampuan Kognitif dan Berpikir Kreatif Siswa Melalui Pembelajaran Berbasis Proyek Berpendekatan STEM)</i>	One-shot case study	2019	√	√	X	X
6	Ariani, L., Sudarmin, & Nurhayati, S.	<i>Analisis Berpikir Kreatif Pada Analysis of Creative Thinking in the Application of Problem Based Learning with Science, Technology, Engineering, and Mathematics Approach (Penerapan Problem Based Learning Berpendekatan Science, Technology, Engineering, and Mathematics.)</i>	One-shot case study	2019	√	√	X	X

No	Author	Title	Study design	Year	C1	C2	C3	Decision
7	Sukmawijaya, Y., Suhendar, S., Juhanda, A.	<i>The Influence of the STEM-PjBL Learning Model on Students' Creative Thinking Ability on Environmental Pollution Material (Pengaruh Model Pembelajaran STEM-PjBL Terhadap Kemampuan Berpikir Kreatif Siswa Pada Materi Pencemaran Lingkungan)</i>	Quasi-experiment with the non-equivalent control group	2019	√	√	X	X
8	Heryanti, A. D.	<i>STEM-Based Learning to Improve Understanding of Energy Concepts and Creative Thinking Skills through the PLTMH Project (Pembelajaran Berbasis STEM Untuk Meningkatkan Pemahaman Konsep Energi dan Keterampilan Berpikir Kreatif Melalui Proyek PLTMH)</i>	Classroom action research	2020	√	√	X	X
9	Khoiriyah, N., Abdurrahman, & Wahyudi, I	<i>Implementation of the STEM Learning Approach to Improve High School Students' Critical Thinking Ability in Sound Wave Material (Implementasi Pendekatan Pembelajaran STEM Untuk Meningkatkan Kemampuan Berpikir Kritis Siswa SMA Pada Materi Gelombang Bunyi)</i>	Quasi experiment Non-Equivalent Pretest-Posttest Control Group	2018	√	√	X	X
10	Dywan, A. A., & Airlanda, G. S.	<i>The Effectiveness of Project Based Learning Learning Model Based on STEM and Not Based on STEM on Students' Critical Thinking Skills (Efektivitas Model Pembelajaran Project Based Learning Berbasis STEM dan Tidak Berbasis STEM Terhadap Keterampilan Berpikir Kritis Siswa)</i>	Quasi experiment Non-Equivalent Control Group	2020	√	√	√	√
11	Afifah, A. F., Ilmiyati, N., & Toto, T.	<i>STEM-Based Project Based Learning (PjBL) Model To Improve Students' Mastery of Critical Thinking Concepts and Skills (Model Project Based Learning (PjBL) Berbasis STEM Untuk Meningkatkan Penguasaan Konsep dan Keterampilan Berpikir Kritis Siswa)</i>	Pre-experiment	2019	√	√	X	X
12	Sukmana, R. W.	<i>Implementation of the Science, Technology, Engineering, and Mathematics (STEM) Approach to Improve Elementary School Students' Critical Thinking Skills (Implementasi Pendekatan Science, Technology, Engineering, and Mathematics (STEM) Untuk Meningkatkan Keterampilan Berpikir Kritis Siswa Sekolah Dasar)</i>	Pre experiment with one group pretest-posttest design	2018	√	√	√	√

No	Author	Title	Study design	Year	C1	C2	C3	Decision
13	Adiwiguna, S., Dantes, N., & Gunamantha, M.	<i>The Effect of STEM-Oriented Model Based Learning (PBL) on Critical Thinking Ability and Science Literacy of Class V Elementary School Students in Gugus I Gusti Ketut Pudja</i> <i>Pengaruh Model Based Learning (PBL) Berorientasi STEM Terhadap Kemampuan Berpikir Kritis dan Literasi Sains Siswa Kelas V SD di Gugus I Gusti Ketut Pudja</i>	Quasi experiment	2019	√	√	√	√
14	Hariyanto, H., Yamtinah, S., Sukarmin, S., Saputro, S., & Mahardiani, L.	<i>Application of Integrated Project Based Learning (PjBL) Model STEM Approach in Improving Students' Concept Understanding in a Tangerang Selatan's School</i> <i>Penerapan Model Project Based Learning (PjBL) Terintegrasi Pendekatan STEM Dalam Meningkatkan Pemahaman Konsep Peserta Didik di Salah Satu Sekolah Daerah Tangerang Selatan</i>	Experiment with posttest only control group design	2019	√	√	X	X
15	Mufidah, I. A., Badarudin, & Yuwono, P. H.	<i>Application of Learning Based on Science, Technology, Engineering, and Mathematics (STEM) to Improve Basic Questioning Skills and Learning Achievement of Elementary School Students</i> <i>(Penerapan Pembelajaran Berbasis Science, Technology, Engineering, and Mathematics (STEM) Untuk Meningkatkan Keterampilan Bertanya Dasar dan Prestasi Belajar Peserta Didik Sekolah Dasar)</i>	Classroom Action Research	2019	√	√	√	√
<b>Concept of STEM-based Learning</b>								
16	Nurazizah, Suwarma, I. R., & Jauhari, A.	<i>Implementation of STEM Learning: Assessment of Students' Learning Outcomes Achievement</i> <i>Implementasi Pembelajaran STEM: Kajian Terhadap Pencapaian Hasil Belajar Siswa</i>	Literature Review	2018	√	√	√	√
17	Artobatama, I.	<i>Outbound Traditional Game Based STEM Learning</i> <i>Pembelajaran STEM Berbasis Outbond Permainan Tradisional</i>	Literature Review	2018	√	√	√	√
18	Permanasari, A	<i>STEM Education: Innovation in Science Learning</i> <i>STEM Education: Inovasi Dalam Pembelajaran Sains</i>	Descriptive analysis	2016	√	√	X	X
19	Rohmah, U. N., Ansori, Y. Z., & Nahdi, D. S.	<i>STEM Learning Approach in Improving Science Literacy Ability of Elementary School Students</i> <i>Pendekatan Pembelajaran STEM Dalam Meningkatkan Kemampuan Literasi Sains Siswa Sekolah Dasar</i>	Literature Review	2019	√	√	√	√

No	Author	Title	Study design	Year	C1	C2	C3	Decision
<b>Development of STEM-based Teaching and Learning Materials</b>								
20	Fatimah, S., Hamdu, G., & Nugraha, A.	<i>Development of Student Worksheets on Outdoor Learning STEM-Based in Primary Schools</i> <i>Pengembangan Lembar Kerja Siswa pada Pembelajaran Outdoor Berbasis STEM di Sekolah Dasar</i>	Educational Design Research	2019	√	√	√	√
21	Erviana, V. Y., & Asmara, A. P	STEM Integrated Encyclopedia as The Enrichment for Elementary School Students STEM Integrated Encyclopaedia as The Enrichment for Elementary School Students	RnD with ADDIE	2019	√	√	√	√
22	Yuanita, & Kurnia, F.	<i>Development of STEM-Based Teaching Materials (Science, Technology, Engineering, and Mathematics) Electrical Materials for Elementary Schools</i> <i>Pengembangan Bahan Ajar Berbasis STEM (Science, Technology, Engineering, and Mathematics) Materi Kelistrikan Untuk Sekolah Dasar</i>	RnD with 4D	2019	√	√	√	√
23	Oktavia, R.	<i>Teaching Materials Based on Science, Technology, Engineering, Mathematics to Support Integrated Science Learning</i> <i>Bahan Ajar Berbasis Science, Technology, Engineering, Mathematics Untuk Mendukung Pembelajaran IPA Terpadu</i>	Literature Review	2019	√	√	√	√
24	Falentina, C. T., Lidinillah, D. A., & Mulyana, E. H.	<i>Wind Powered Car: STEM Based Media for Class IV Elementary School Students</i> <i>Mobil Bertenaga Angin: Media Berbasis STEM untuk Siswa Kelas IV Sekolah Dasar</i>	Educational Design Research	2018	√	√	√	√
25	Utami, T. N., Jatmiko, A., & Suherman, S.	<i>Mathematics Module Development with Science, Technology, Engineering, and Mathematics (STEM) Approach in Quadrilateral Subjects</i> <i>Pengembangan Modul Matematika Dengan Pendekatan Science, Technology, Engineering, and Mathematics (STEM) Pada Materi Segiempat</i>	RnD	2018	√	√	X	X
26	Madyani, I., Yamtinah, S., & Utomo, S. B.	<i>The Development of LKPD Science Integrated PBL Model of STEM Material Temperature and its Changes</i> <i>Pengembangan LKPD IPA Model PBL Terintegrasi STEM Materi Suhu dan Perubahannya</i>	RnD	2019	√	√	X	X

No	Author	Title	Study design	Year	C1	C2	C3	Decision
27	S. Setiawaty, R. Imanda, H.	<i>Development of STEM-Based Science Worksheets for Elementary School Students</i>	RnD	2020	√	√	√	√
28	Fitriani, R.P. Sari Maula, N. R., & Fatmawati, L.	<i>Pengembangan LKS Sains Berbasis STEM Untuk Siswa Sekolah Dasar Development of Learning Media for Kayaku (Kayanya Alam Negeriku) STEM- Based in 4<sup>th</sup> Grade of Elementary Schools Pengembangan Media Pembelajaran Kayaku (Kayanya Alam Negeriku) Berbasis STEM Kelas IV Sekolah Dasar</i>	RnD	2020	√	√	√	√
<b>Teacher Training on STEM Education</b>								
29	Sukmana, R. W.	<i>Science, Technology, Engineering, and Mathematics (STEM) Approach as an alternative in Developing the Learning Interest of Elementary School Students Pendekatan Science, Technology, Engineering, and Mathematics (STEM) Sebagai Alternatif dalam Mengembangkan Minat Belajar Peserta Didik Sekolah Dasar</i>	Observation	2018	√	√	√	√

The search process results imply that research on elementary STEM education in Indonesia within the last 5 years is mostly related to finding best practices of STEM-based learning to foster certain skills or understanding (15 articles). In addition, research aim to develop various teaching and learning resources to support STEM learning. The other 4 research analyse and present possible models for STEM-learning implementation at school. However, there is only one research that studies the impact of teacher training on teacher’s understanding of STEM education.

The selection process using inclusion and exclusion criteria of 29 articles aims to decide whether the data found is suitable for use in this SLR research or not. 16 articles that met all criteria were then run through quality assessment regarding its relevance to RQ1, RQ2 and RQ3. The quality assessment result shows that 15 articles have sufficient information regarding STEM-learning in elementary school in Indonesia and therefore can be used to answer all research questions in this study. Further trends in STEM research at the elementary school level is discussed in the next section.

## DISCUSSION

### RQ1. What is the focus of study in research related to STEM learning in Indonesian elementary schools?

Overall, 29 journals go through quality assessment after selecting data based on inclusion and exclusion criteria. There are 15 relevant journal articles from the quality assessment which is grouped based on the focus of the study. The results of RQ1 are shown in **Table 2**.

**TABLE 2.** Focus of study related to STEM-based learning in elementary school

Focus of Study	Author	Number of articles
STEM-based Teaching & Learning Media	Maula & Fatmawati, 2020; Setiawaty, et.al., 2020; Erviana & Asmara, 2019; Fatimah, Hamdu & Nugraha, 2019; Madyani, Yamtinah & Utomo, 2019; Oktavia, 2019; Yuanita & Kurnia, 2019; Falentina, Lidinillah & Mulyana, 2018	7
STEM impact on learning achievement in general	Artobatama, 2018; Nurazizah, Suwarma & Jauhari, 2018	2
STEM impact on critical thinking skill	Dywan & Airlanda, 2020; Sukmana, 2018	2
STEM impact on scientific literacy	Rohmah, Ansori & Nahdi, 2019	1
STEM impact on questioning skill	Mufidah, Badarudin & Yuwono, 2019;	1
STEM impact on creative thinking skill	Amiruddin, Juwairiyah & Subhan, 2019	1
STEM impact on critical thinking skill and scientific literacy	Adiwiguna, Dantes, & Gunamantha, 2019	1
Total		15

As seen from **Table 2**, most of the study aims to develop teaching and learning materials to support STEM learning at the elementary school level. Ranging from worksheets, modules, and different kinds of learning media, including digital interactive media and supplementary media, enhance STEM learning in and outside the classroom.

Learning outcomes studied as the independent variable in research related to STEM learning in elementary schools include critical thinking skills, general learning outcomes,

scientific literacy skills, basic questioning skills, and creative thinking skills. Based on a review of several journal articles studied, it is known that the effect of STEM learning on critical thinking skills in elementary schools has been most closely examined.

## **RQ2. How is STEM Learning Implemented in Indonesian Elementary Schools?**

STEM learning is very suitable to be integrated with thematic learning in elementary schools. It is because STEM learning integrates various subjects as well as thematic. STEM can be implemented by various learning models (Nurazizah, Suwarma, & Jauhari, 2018; Adiwiguna, Dantes, & Gunamantha, 2019). One of them is through the application of the problem-based learning (PBL) model. There are five stages of implementing STEM-based problem-based learning (PBL) models in elementary schools: the problem orientation stage, the problem organizing stage, the investigation stage, the development stage and presentation of results, and the analysis and evaluation stage.

Besides, STEM learning in elementary schools can be integrated through the project-based learning (PjBL) model (Dywan & Airlanda, 2020). There are five stages of implementing STEM-based project-based learning (PjBL) learning in elementary schools: the reflection stage, the research stage, the discovery stage, the application stage, and the communication stage.

The application of STEM learning is integrated through various media to support the learning process. According to (Maula & Fatmawati, 2020), various learning media can be developed and utilized to support STEM learning in elementary schools, one of which is the STEM-based learning media called Kayaku. This media can involve students in exploring material and solving problems with digital content and sources. This learning media is found to help develop the creativity and ability of teachers to create interactive learning. Another study was done by (Erviana, 2019) developed a thematic STEM encyclopaedia to help students increase their understanding and improve critical and creative thinking skills. STEM-based learning can also be supported by using integrated teaching materials (Oktavia, 2019), such as STEM-based teaching material for electricity concepts (Yuanita & Kurnia, 2019).

Within STEM learning, engineering activities enable the students to construct products, such as wind-powered cars (Falentina, Lidinillah, & Mulyana, 2018). By making of wind-powered car media, students were exposed to the application of changes in motion energy due to wind. The wind-powered car activity is intended for fourth-grade elementary school students. Using of these engineering activities makes students able to round up numbers obtained measurement They were making a wind-powered car also able to provide students with meaningful learning through direct experience.

Besides using certain learning media, STEM learning is also implemented through traditional game-based outbound learning. This learning process uses traditional game materials, processes, and functions, which are integrated with STEM learning so that students can play and gain knowledge whilst playing games. The application of a combination of traditional game-based outbound learning is carried out outside the field, providing the first-hand experience. The application of STEM learning based on traditional outbound games in elementary schools aims to help students understand technology without forgetting traditional games' richness. Similarly, in research done by (Fatimah, Hamdu, & Nugraha, 2019), STEM learning can be implemented in the outdoor settings facilitated by STEM-based students' worksheet. STEM-based worksheets can be developed in relevance to Kurikulum 2013 and designed in such a way to help students acquire conceptual understanding and science process skills (Setiawaty, Imanda, & Fitriani, 2020).

### **RQ3. What are the results of the research on STEM learning in Indonesian elementary schools?**

Various studies have proven that STEM-based learning can increase self-potential in elementary school students. Research conducted by Dywan & Airlanda (2020) on fourth-grade students proved that the STEM-based Project Based Learning (PjBL) model succeeded in improving students' critical thinking skills. It is evident by the increase in the pre-test and post-test scores. Similarly, Adiwiguna, Dantes, & Gunamantha (2019), who performed research on fifth-grade students, successfully proved that applying of the problem-based learning (PBL) model with STEM approach was able to improve students' critical thinking skills and scientific literacy. In addition, Sukmana, (2018) succeeded in improving students' critical thinking skills with the Science, Technology, Engineering, and Mathematics (STEM) approach of grade IV of one of public school in Bandung. This study shows that the STEM approach is proven to improve students' critical thinking skills. Increasing critical thinking skills through the STEM approach can be seen from the results of student questionnaires which prove that as many as 80% of grade IV students state that learning using the STEM approach is attractive and provides space for students in the problem-solving process. Amiruddin, Juwairiyah, & Subhan (2019) also found out that STEM learning in elementary school can significantly improve students' critical thinking as students familiar with conducting analysis and synthesis in which it is indeed the essential part in creative thinking abilities. On the other hand, (Rohmah, Ansori, & Nahdi, 2019) suggests that STEM learning can improve elementary school students' scientific literacy. It trains students to understand their environment and the problems faced by the modern society which is very dependent upon the development of science and technology.

Mufidah, Badarudin, & Yuwono (2019) researched on applying STEM learning to increase achievement and basic questioning skills of fourth-grade students in one of the elementary schools in Karangkedawung, Central Java. This study proved that STEM-based learning provided an increase in students' ability to ask fundamental questions before the application of STEM lacked criteria. In contrast, after implementing STEM learning, it increased to an outstanding category.

Artobatama, (2018) researched on STEM learning based on traditional outbound games for fourth-grade students in one of the elementary schools in Pangkal Pinang. This study proves that STEM learning integrated with outbound games has succeeded in attracting students' interest in actively learning. Outbound traditional game-based STEM learning also makes learning interactive and less tedious.

Moreover, STEM-based teaching and learning media have made a positive contribution to elementary school students' learning process. Previous studies prove that the application of STEM-based teaching and learning materials is very suitable for use in elementary schools. For instance, STEM-integrated encyclopaedia is suitable for STEM learning for grade five covering heat and temperature topic (Erviana and Asmara, 2019). Learning materials on electricity topics developed based on STEM principles are also found to have high feasibility to be used in grade 6 (Yuanita & Kurnia, 2019). This learning materials consist of several sections covering science, technology, engineering, and mathematics indicators rooted in electricity. Referring to Oktavia (2019), STEM-based learning materials can be developed to support integrated science lesson. The development of teaching materials can be done using webbed, connected, shared, or integrated models depending on the topic's characteristics.

The Development of STEM-based learning materials or modules also found to support STEM learning in grade 4 elementary school. According to Falentina, Lidinillah, & Mulyana (2018), wind-powered car media fit to support STEM learning in grade 4 covering energy changes and rounding measurement results as science and mathematics topics. On the other hand, Setiawaty et. al. (2020) develops a worksheet related to the Caring Living Things theme in grade 4. These STEM-based science worksheets have met the eligibility

standards referring to BSNP and are suitable for use in learning, based on content, presentation, language, and graphics. Differently, Maula and Fatmawati (2020) develop STEM-based interactive media to support grade 4 learning in Natural Resources and Energy called Kayaku. This media is categorized as very feasible to be used as a learning media and fosters students' motivation in learning and reading and improves their conceptual understanding of the theme.

According to the elaboration of each RQs, various studies have proven the impact of STEM learning on various student learning outcomes and can be supported by various media and teaching materials in enhancing teaching and learning activities at the elementary level. The trends that can be identified are most studies focus on developing STEM-based teaching and learning materials, while others focus on identifying the impact of STEM-based lessons on various learning achievement. This finding is in line with the trends in the international research community who had a broad interest in both teaching and learning in K-12 STEM education (Li, et al., 2020).

Nonetheless, as indicated in Table 2, only two out of 4Cs of 21<sup>st</sup> Century Skills being studied, namely critical thinking and creative thinking skills. None of the articles studies the impact of STEM learning on the other 2Cs of elementary school students', namely collaboration and communication skills. Project-Based Learning (PjBL) has evidenced success in enhancing students' communication and collaboration skills (Owens & Hite, 2020; Nuraeni, Permanasari, & Riandi, 2018), and can be integrated with the STEM approach (Dywan & Airlanda, 2020). Therefore, studies on STEM learning with PjBL and its impact on communication and collaboration skills are potential.

In addition, from 15 articles reviewed, it is found that the research mainly focuses on STEM-based learning practices in higher elementary, involving students in grade four to six as the participant of the study. On the other hand, STEM is applicable in lower grades of elementary too. For example, in one third-grade Turkish primary school, STEM activities can be integrated with the 5E (enter, explore, explain, elaborate, evaluate) instructional model to help students learn about Matter's topic (Ültay, et al., 2020). Another research also involved children aged four to eight years old to experience integrated STEM and robot-based approaches resulted in scientific literacy enhancement (Dufranc et al., 2020). These facts might give promising results for more movement in STEM practices for lower elementary school grades in Indonesia.

## CONCLUSION

Based on the findings from our systematic literature review about STEM learning in Indonesian elementary school, it can be concluded that many studies have great interest in developing STEM-based teaching and learning materials, while some other focus on identifying the impact of STEM-based learning on various elementary student learning achievements such as creative thinking skills, critical thinking skills, basic questioning skills, scientific literacy skills, and learning achievement in general. STEM-based learning can be implemented at the elementary school level and supported by feasible teaching and learning media and materials. The implementation of STEM learning in Indonesian elementary schools is integrated with the problem-based learning (PBL) learning model and the project-based learning (PjBL) learning model.

The article used in this study is limited to articles published in Indonesian national journal or proceeding published by national institution within 2015 to 2020. Further study can be done with broad scope involving publication in international journals or proceeding as well. Larger scope of article selection over a longer period of publication time might also be beneficial to better understanding on the trends and development of STEM education at the elementary school level in Indonesia. In addition, the availability of study related to STEM-based learning in lower elementary (grade 1 to 3) and study on the

impact of STEM-based learning on students' collaboration and communication skills are still limited. Therefore, a further researcher might consider researching in this scope.

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