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A Systematic Literature Review of STEM Education in Indonesia (2016-2021): Contribution to Improving Skills in 21st Century Learning

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Abstract

STEM (Science, Technology, Engineering, and Mathematics) education is an alternative learning approach to constructing 21st century skills. It encourages the emergence of innovation to develop these skills. The study uses a systematic literature review method adapted from Sharif and Moher *et al.* using PRISMA. The content analysis aimed to systematically analyze trends in STEM or STEAM education research in Indonesia using articles published in national and international journals. From the inclusion criteria, there were 63 articles collected analyzed using the Paper Classification Form (PCF) instrument adapted from Kizilaslan *et al.* with indicators title, author, author nation, journal name, year publishing, journal type, language, index, principal discipline, research method, data collection, sample, and data analysis. The findings indicate that the dominant topic is learning strategies with experimental research methods. STEM or STEAM education dominates at the secondary school level for science subjects. Project-based learning, problem-based learning, and Inquiry are the dominant learning models integrated with STEM or STEM learning. Critical thinking ability, scientific literacy, and learning outcomes are the dominant theme in STEM or STEAM education. Empirical research is needed on the potential of STEAM education to improve skills in 21st-century learning.

Keywords: Indonesia, STEM education, STEAM education, systematic literature review.

Introduction

STEM (Science, Technology, Engineering, and Mathematics) was initiated in the 1990s by the National Science Foundation in the United States (Arifin *et al.*, 2021). STEM is a learning alternative to build 21st century abilities and skills (Petersburton & Stehle, 2019) and face the challenges of industry 4.0 (Farwati *et al.*, 2021). The STEM education goal is to integrate multidisciplinary science as the key to deep understanding and meaningful learning (Baharin *et al.*, 2018)Technology, Engineering and Mathematics (STEM.

STEM education in Indonesia began in 2014 based on the findings of the Google Scholar database. Handayani (2014) developed teaching materials (worksheets) based on STEM in chemistry subjects. Over time, STEM began to become the focus of educational research. The number of articles using the keyword "STEM Education" is 5.490, while "STEAM Education" has as many as 526 from 2016 to 2021.

The Indonesian government has not issued an official policy regarding STEM education in the curriculum (Ardwiyanti *et al.*, 2021). However, various empirical studies have begun implementing STEM education in most recent is STEAM education in classroom learning. The study theoretically discussed using a systematic subject is needed that aims to examine STEM or STEAM trends in the context of education.

In the international world, STEM or STEAM education research has been applied in several countries such as the United (Upadhyay *et al.*, 2021), Russia (Shukshina *et al.*, 2021), South Korea (Kang, 2019; Park *et al.*, 2016), Nepal (Belbase, 2019), and other Asia-Pacific region countries (Chu, 2021). There is the theoretical framework by Aguilera & Ortiz-Revilla (2021), its integration with inquiry-based learning by Zhai (2019), a systematic literature review on trends by (Li *et al.*, 2020)., the effect of project-based learning using STEM-integrated by Lou *et al.* (2017) and the key concepts

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and learning theory to build an integrated the framework by Kelley & Knowles (2016).

Several previous studies have also investigated the trend of STEM education research in Indonesia. A Systematic Literature Review (SLR) of STEM education trends in science learning (Physics, Biology, Chemistry) using articles published from 2001 until 2020 with inclusion criteria, namely national journals accredited at least Sinta 3 and accredited DOAJ by Ardwiyanti *et al*., (2021), a scoping review using articles published from 2015 until 2020 with inclusion criteria, namely conference proceedings, and journals by Farwati *et al*., (2021) as well as SLR-based Bibliometric Mapping using articles published from 2016-2020 with inclusion criteria, namely conference, and journal proceeding by Arifin *et al*., (2021). Based on previous research, there is a difference in this SLR using articles published in 2016 - October 2021 with minimum inclusion criteria in an accredited journal Sinta 2, or indexed by Scopus. It is purposed to ensure the extent to which STEM or STEAM education research in Indonesia is equivalent to the development in the international world.

The detail of Research Questions (RQ) to help gather relevant information, including:

RQ 1:	What are the most explored topics from STEM or STEAM education research on science learning in Indonesia from 2016-October 2021?
RQ 2:	How is the STEM or STEAM education implementation in science learning?
RQ 3:	How is the integration of STEM or STEAM education in Indonesia?
RQ 4:	What are the dominant themes associated with STEM or STEAM education?
RQ 5:	What is the most potential research topic to be developed in the future?

Method

Research Design

This study used a systematic literature review with a content analysis approach that involves scientific articles related to STEM or STEAM education in science subjects from 2016-October 2021 in Indonesia. Higgins (2019) explains that a systematic literature review is essential to implement. It is inspiring to recognize the priority of studies and see the initial conceptual framework in the future and the level of one's knowledge of appropriate authoritative decisions. For more context, a systematic literature review is to sharpen the information obtained.

Population and Sampling

The sample of this study consists of 63 articles. The articles published in the field of STEM or STEAM education from 2016 to October 2021 and included in the Google Scholar, Garuda, and ERIC database of this research using the keywords "STEM Education", "STEAM Education", "STEM Indonesia" and "STEAM Indonesia."

Data Collection Tools

The procedure of systematic literature review in this study adapted the data selection stage from Sharif (2019) and Moher *et al*., (2019) following the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses).

Data Collection

The stages of review include:

1. Data selection
    1. Formulation of research questions and identification articles
    2. Determination of inclusion criteria (See Table 1)
    3. Screening articles in various databases (Google Scholar, Garuda, and ERIC)

We reduce the articles according to the criteria. A total of 63 manuscripts we studied and analyzed by reviewing the abstract and reading the entire contents.

2. The coding instrument was adapted Paper Classification Form (PCF) developed by Kizilaslan *et al*., (2012). It is qualified for the validity and reliability requirements. The indicators used in the PCF include title, author, author nation, journal name, year publication, journal type, language, indexes, main discipline, research methods, data collection, sample, and data analysis. Researchers also create a data matrix that includes research purposes, integrated learning models, themes, and findings. Furthermore, the collected data were analyzed using percentage calculations.
3. Identify article patterns, namely findings, integration of STEM or STEAM education, and skills achieved. Synthesize patterns to answer research questions. Identify article patterns, namely findings, integration of STEM or STEAM education, and skills achieved.
4. Synthesize patterns to answer research questions. (Figure 1)

Data Analysis

In this step, we calculated the percentage of each finding and investigated the cause with the relevant research (Table 2).

Table 1: Inclusion and Exclusion Criteria

No	*Category*	*Inclusion Criteria*	*Exclusion Criteria*
1	Type of publication	Articles published in journals	Articles published in proceeding conference, book, website or blog, and others.
2	Journal specifications	National journal minimum accredited Sinta 2 and international journal indexed Scopus.	National journal not accredited or accredited Sinta 3 until 5 and international journal not indexed Scopus.
3	Publication year	2016 - October 2021	Less than 2016
4	Research Setting	Indonesia	overseas
5	Research's nationality	Indonesian, a collaboration of Indonesians and foreigners	Only foreigners
6	Independent variable	STEM or STEAM	Not STEM or STEAM
7	Field	Science (Chemistry, Physics, Biology)	Outside of science
8	Research Subject	Student's and teacher's informal education includes early childhood school, elementary school, secondary school, senior high school, vocational high school, and university	Students and teachers in nonformal schools or special needs school

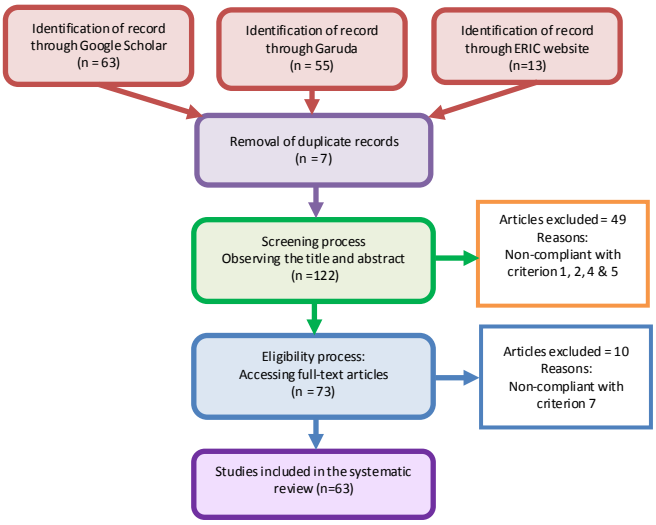

Fig. 1: Flowchart of the article selection procedure

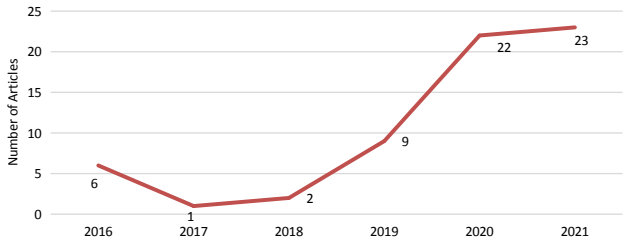

Fig. 2: Distribution of Article by Year Published

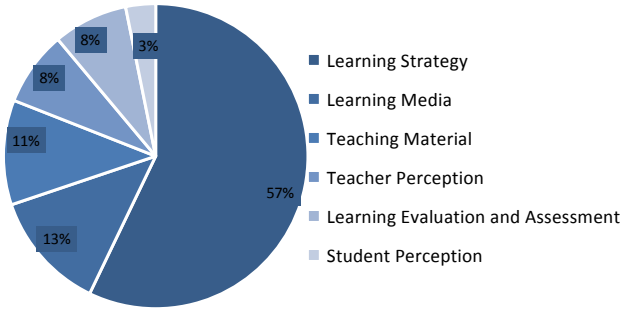

Fig. 3: Distribution of STEM or STEAM education research topic

Findings

This systematic literature review examines articles published from 2016-October 2021 conducted in Indonesia. Distribution of articles with journal identification using inclusion criteria, namely nationally accredited journals with Sinta 1 and 2, also international journals indexed by Scopus Q1, Q2, Q3, and Q4 (See Table 2). Research dominated on STEM or STEAM education is the Jurnal Pendidikan IPA Indonesia (10 manuscripts), Jurnal Pendidikan Sains Indonesia (7 manuscripts), and Journal for the Education of Gifted Young Scientists (5 manuscripts).

Research on STEM or STEAM education in Indonesia discusses various topics. The topic of learning strategies dominates research on STEM or STEAM education, followed by learning media and teaching materials. Teacher perceptions, learning evaluation and assessment, and student perceptions are minor topics (See Fig. 3).

Based on these findings, the research methods used in STEM or STEAM education research were analyzed.

Research on STEM or STEAM education exists in various provinces. The following is the distribution of STEM or STEAM education research in science learning (Figure 4).

The implementation of STEM or STEAM education in science learning is most often found in East Java, then in West Java and Central Java provinces (See Fig. 4). Meanwhile, other provinces that have started implementing it include DKI Jakarta, Special Region of Yogyakarta, Lampung, West Nusa Tenggara, East Nusa Tenggara, Aceh, South Sulawesi, Madura, Riau and Banten. Of the 34 provinces in Indonesia,

Table 2: Distribution of Articles with Journal Identification

Type of journal	*Rank*	*Journal Name*	*Frequency*	*Percentage (%)*
Nasional	Grade 1 (Sinta 1) accredited and Scopus Q2 indexed	Jurnal Pendidikan IPA Indonesia	10	15,9
		Telkomnika	1	1,6
	Grade 2 (Sinta 2) accredited	Jurnal Inovasi Pendidikan IPA	3	4,8
		Jurnal Pendidikan Sains Indonesia	7	11,1
		Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan	3	4,8
		Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini	4	6,3
		Jurnal Pendidikan Biologi Indonesia (JPBI)	3	4,8
		Jurnal Pendidikan Indonesia	2	3,2
		Journal of Educational Science and Technology	1	1,6
		Premiere Educandum: Jurnal Pendidikan Dasar dan Pembelajaran	2	3,2
		Tadris: Jurnal Keguruan dan Ilmu Tarbiyah	1	1,6
		Jurnal Penelitian Pendidikan IPA	3	4,8
		Jurnal Kependidikan	1	1,6
		Al Bidayah : Jurnal Pendidikan Dasar Islam	1	1,6
		Jurnal Ilmiah Sekolah Dasar	2	3,2
		Jurnal Pendidikan Usia Dini	1	1,6
International	Scopus Q1	Cultural Studies of Science Education	1	1,6
	Scopus Q2	Sustainability	1	1,6
		International Journal of Instruction	1	1,6
	Scopus Q3	Journal for the Education of Gifted Young Scientists	5	7,9
		European Journal of Educational Research	2	3,2
		Turkish Journal of Computer and Mathematics Education	3	4,8
		International Journal of Environmental & Science Education	1	1,6
		Review of International Geographical Education	1	1,6
	Scopus Q4	Universal Journal of Educational Research	2	3,2
		International Journal of Evawluation and Research in Education (IJERE)	2	3,2
Total			63	100

Table 3: The Trend of STEM or STEAM Education from Research Methods

Approach	Research Methods	Frequency	Percentage (%)
Qualitative	Literature Review	2	3,2
	Comparative Study	1	1,6
	Phenomenology	1	1,6
	Descriptive	7	11,1
Quantitative	Experiment	23	36,5
	Survey	8	12,7
The Other	Mixed Method	8	12,7
	Research and Development	12	19,0
	Classroom Action Research	1	1,6

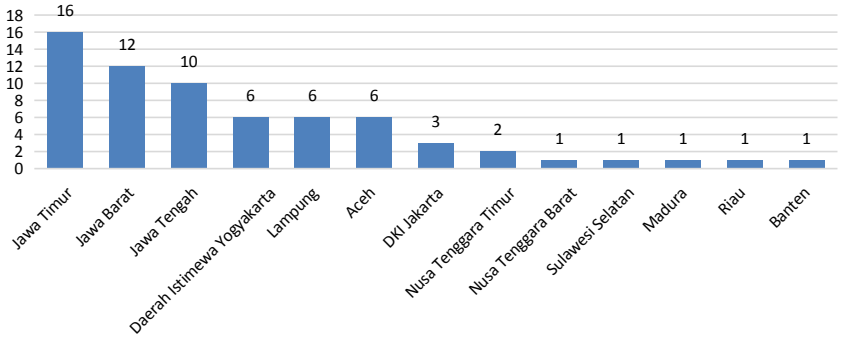

Fig. 4: Distribution of STEM or STEAM education implementation research locations

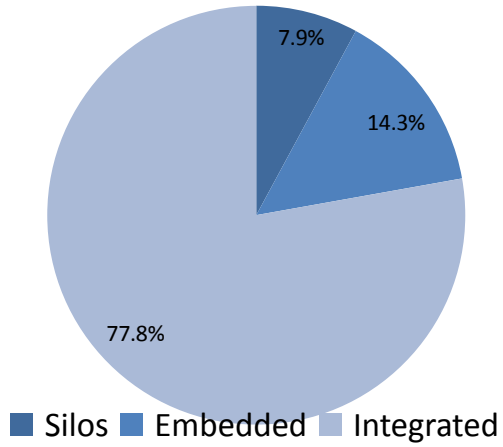

Fig. 5: Distribution of STEM or STEAM approaches in science learning in Indonesia

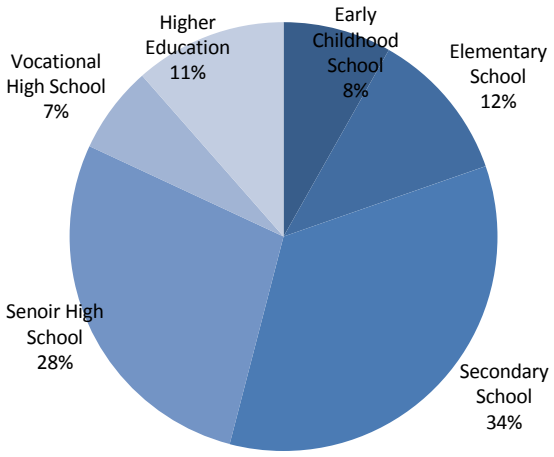

Fig. 6: Distribution of integration of STEM or STEAM education at each level

Table 4: Integration Learning Strategy of STEM or STEM Education

Learning Strategy	*Percentage (%)*	*Reference*
Project-Based Learning	30,2	Afriana *et al.* (2016a); Afriana *et al.* (2016b); Fithri *et al.* (2021); Nuraeni *et al.* (2020); Purwaningsih *et al.*, (2020); Setyaningsih *et al.* (2021); Suratno *et al.* (2020); Susilo *et al.* (2019); Syukri *et al.*, (2021); Wardani *et al.* (2021); Widarti *et al.* (2020); Yakob *et al.* (2021); Badriyah *et al.* (2020); Anekawati *et al.* (2021); Riyanti *et al.* (2020); Putri & Taqiudin (2021); Amalia *et al.* (2021); Fadhilah *et al.* (2021); Adriyawati *et al.* (2020); (Haryanto *et al.*, 2021)
Problem Based Learning	14,3	Hasanah *et al.* (2021)students do not use LKPD to do practical work optimally, so the biology learning process in schools does not encourage students to practice critical thinking skills. This study aims to improve students' critical thinking skills by using the PBL learning model combined with STEM-based worksheets on environmental pollution conceptin class 10th SMA Negeri Bireuen district. The approach used is experimental design, the method used is quasi-experimental, with a pretest-posttest design non-equivalent control group design. Population in class 10th IPA SMAN 1 and SMAN 2 Peusangan designed 252 people. The sampling technique used was purposive sampling technique. The research sample was 140 students. The number of samples in the experimental class was 71 people and 69 people in the control class. The instrument used was a reasoned multiple choice question accompanied by a rubric. The data analysis used was n-gain and independent t-test. The results showed that the critical thinking skills obtained was 0.93, with an increase in class critical thinking skills including the high category. The results of the independent sample t-test obtained Sig. (0,000; Isatunada & Haryani (2021); (Nurtanto *et al.*, 2019); Madyani *et al.* (2019)and the N-gain test to determine the effectiveness of the learning method applied. The results of this study indicate that: (1; Nuraeni *et al.*, (2020); Nurtanto *et al.*, (2020b); Parno *et al.* (2020)whereas research about the implementation of Problem Based Learning-Science Technology Engineering and Mathematics (PBL-STEM; S. F. Putri & Istiyono (2017); Rivai & Yuliati (2018); Setyaningsih *et al.* (2021)

Learning Strategy	*Percentage (%)*	*Reference*
Inquiry	9,5	Abdurrahman *et al.* (2019); Bukifan *et al.* (2020); Hidayati & Irmawati (2019)technology, engineering, and mathematics (STEM; Isdianti *et al.* (2021); Ismail *et al.* (2016); Pahrudin *et al.* (2021)including Indonesia. Indonesia responded quickly through technological developments, especially education. The actions of the Indonesian government to deal with industrial 4.0 are contained in the 4C principle, one of which is Critical Thinking. The Science, Technology, Engineering, and Mathematics (STEM
Blended Learning	6,3	Ardianti *et al.* (2020); Lestari *et al.* (2021); Ngabekti *et al.*, (2019)legibility and effectiveness of STEM Mobile Learning Package ecosystems on students' science and technology literacy using R & D research design. STEM Mobile Learning Package was validated by media experts and material experts. The level of legibility is measured by questionnaire through the results of a small-scale trial of a Biology student class. The effectiveness of the application was measured in wide-scale test for biology and natural science students. Data were analyzed using descriptive quantitative. The results showed the the validity on learning package from experts showed valid in 83,6%. Some revisions are needed especially on video aspect which will be better filled with not only text but also voice. Base on data collected from 47 students who have completely filled 12 statements in questionnaire, about 78,7% students stated they could understand the questions very well. Most of students (97,8%; Setyaningsih *et al.* (2021)
HOTS	4,8	Rosidin *et al.* (2019); Syadiah & Hamdu (2020); Sofia *et al.* (2020)Technology, Engineering, Art and Mathematics (STEAM
Learning Cycles	4,8	Agustina *et al.* (2020); Debora & Pramono (2021); Khaeroningtyas et al., (2016)
Loose Part	3,2	Rahardjo (2019); Wahyuningsih *et al.* (2019)
AKA (Attitude, Knowledge and Applications)	3,2	Parmin *et al.* (2020); Wahono & Chang (2019)
AT (Attitude Toward)-STEM	3,2	Perdana *et al.* (2021); Suprapto (2016)
Scientific Literacy	3,2	Sulistiyowati *et al.* (2018)Technology, Engineering, and Mathematics; Wahyu *et al.* (2020)
Discovery Learning	3,2	Fadlina *et al.* (2021); Purwaningsih *et al.* (2020)Technology, Engineering, and Mathematics-Project Based Learning (STEM-PjBL
Engineering Design Process (EDP)	1,6	Nurtanto, *et al.* (2020a)
Contextual Learning	1,6	Rusydiyah *et al.* (2021)
Entrepreneurial Science Thinking	1,6	Sagala *et al.* (2019)
Indigenous Science	1,6	Sumarni *et al.* (2021)
Cooperative Learning	1,6	Firdaus *et al.* (2020)
Scientific Approach	1,6	Kaniawati *et al.* (2021)
Game	1,6	Ahmad *et al.* (2021); (Nurtanto *et al.*, 2021)
Local Wisdom	1,6	Rosana *et al.* (2021)Technology, Engineering, and Mathematics
KQ (Knowledge Questionnaire)	1,6	Thaha *et al.* (2021)

38% have implemented science learning with STEM or STEAM education.

The findings of this study indicate that there are three approaches applied in the implementation of STEM or STEAM education in Indonesia (Figure 5).

The integrated STEM or STEAM approach has been widely used in the implementation of science learning in Indonesia (See Fig. 5). While other approaches, namely embedded and silos have also been applied in science learning. Implementation of science learning with STEM or STEAM education integrated with various learning models will make students able to bring up some of the competencies that are expected by learning objectives.

STEM education has been widely implemented in Indonesia at every level of education (See Fig. 6). The most interesting implementation is at the secondary school (Figure 6).

Implementing STEM or STEAM learning can be integrated with various learning strategies (See Table 4).

STEM education is always associated with a certain theme in research. Table 5 shows the distribution of findings from this systematic literature review based on research themes.

Table 5: Distribution of Themes Associated with STEM or STEAM Education

No	*Theme*	*Frequency (%)*
1	Mastery concept	6,6
2	High order thinking skills (HOTS)	2,6
3	Scientific literacy	18,4
4	Critical thinking	18,4
5	Scientific thinking	1,3
6	Science process skills	6,6
7	Creativity skills	7,9
8	Student liveliness	1,3
9	Learning interest	1,3
10	Learning achievement	15,8
11	Technology literacy	1,3
12	Collaboration skills	1,3
13	Attitude	3,9
14	21st century skills	1,3
15	Learning independence	1,3
16	Indigenous science	1,3
17	Problem solving	9,2

Discussion

Topics of STEM or STEAM Education Research

STEM research has increased from year to year (See Fig. 2). STEM education is a new research theme in Indonesia compared to other research themes. Currently also appears STEAM education with the addition of "Arts" in it as a development of STEM education. Kizilaslan et al., (2012) stated that it is not surprising that STEM education research begins with a fundamental topic in curriculum reform that focuses on learning strategies.

STEM or STEAM education research in Indonesia is implemented on various topics. The topic of learning strategy dominates STEM or STEAM education research, followed by learning media and teaching materials. Teacher perception, learning evaluation and assessment, and student perception are topics that are minor discussed (See Fig. 3). The findings are in line with research trends from 2015 to 2020 in Indonesia (Ardwiyanti *et al*., 2021) dominated by learning strategy, teaching materials, and learning media. The topic of teaching materials includes worksheets, assisted by video, modules, and indigenous science. Meanwhile, learning media topics include digital multimedia, virtual labs, mobile learning, books, loose parts, augmented reality, and water rockets. The findings of this study are also in line with international research trends, where research topics that dominate STEM education are related to curriculum, policy, evaluation, and assessment (Li *et al*., 2020).

Trends in STEM or STEAM education in terms of research methods that dominate used in Indonesia are experimental, research and development, survey, and mixed methods (See Table 3). Li *et al*. (2020) explain that experimental is the dominant method followed by qualitative research and mixed methods. The findings of this SLR research show that Indonesian researchers are still relatively low in conducting a literature review, classroom action research, phenomenology, and comparative study.

STEM or STEAM Education on Science Learning Implementation

STEM education is an integration of four inseparable components related to various situations and experiences of everyday life (Pimthong & Williams, 2020; Reyza et al., 2020). STEAM education is part of STEM with the addition of elements of art (Bertrand & Namukasa, 2020). STEM or STEAM learning is integrated with certain learning models, methods, approaches, competence, or context (English, 2016; Stohlmann et al., 2012).In its implementation, STEM or STEAM education is divided into three, namely the silos approach, embedded approach, and integrated approach (Margot & Kettler, 2019; Roberts & Cantu, 2012). In the silos approach, the learning taught in each STEM discipline is separated from each other to allow students to gain a deeper understanding of one subject topic (Reyza *et al*., 2020).

The embedded approach in science learning is emphasized content and techniques as in the silos approach, but the difference in the embedded approach lies in the implementation of learning which is more emphasized in reviewing several contexts (Rossouw *et al*., 2011). The realm of engineering and technology is implanted through STEM learning (Reyza *et al*., 2020). This approach raises competencies in various subjects so that competency limits are determined to achieve learning objectives (Nurtanto *et al*., 2020b).

The further is an integrated approach. An integrated approach in STEM education is carried out to fuse its components and make it a subject in learning (Breiner *et al*., 2012). In contrast to the embedded approach, the integrated approach allows students to gain mastery of the competencies needed to solve problems in everyday life by integrating all components in STEM education (Lou *et al*., 2011).

In science learning, STEM or STEAM education is most often integrated with the Project-Based Learning model. This was followed by integration with problem-based learning and Inquiry learning models (See Table 3). These findings are in line with empirically proven research for integration with project-based learning models (Wardani *et al*., 2021; Fithri *et al*., 2021; Priatna *et al*., 2020; Afriana *et al*., 2016a) while integration with the problem-based learning model (Hasanah *et al*., 2021;students do not use LKPD to do practical work optimally, so the biology learning process in schools does not encourage students to practice critical thinking skills. This study aims to improve students' critical thinking skills by using the PBL

learning model combined with STEM-based worksheets on environmental pollution conceptin class 10th SMA Negeri Bireuen district. The approach used is experimental design, the method used is quasi-experimental, with a pretest-posttest design non-equivalent control group design. Population in class 10th IPA SMAN 1 and SMAN 2 Peusangan designed 252 people. The sampling technique used was purposive sampling technique. The research sample was 140 students. The number of samples in the experimental class was 71 people and 69 people in the control class. The instrument used was a reasoned multiple choice question accompanied by a rubric. The data analysis used was n-gain and independent t-test. The results showed that the critical thinking skills obtained was 0.93, with an increase in class critical thinking skills including the high category. The results of the independent sample t-test obtained Sig. (0,000 Parno *et al*., 2020;whereas research about the implementation of Problem Based Learning-Science Technology Engineering and Mathematics (PBL-STEM Madyani *et al*., 2019;and the N-gain test to determine the effectiveness of the learning method applied. The results of this study indicate that: (1 Rivai & Yuliati, 2018) and integration with the STEM-Inquiry model (Isdianti *et al*., 2021; Pahrudin *et al*., 2021)including Indonesia. Indonesia responded quickly through technological developments, especially education. The actions of the Indonesian government to deal with industrial 4.0 are contained in the 4C principle, one of which is Critical Thinking. The Science, Technology, Engineering, and Mathematics (STEM.

STEM or STEAM education can help students to solve problems, conclude and apply their knowledge (Lou et al., 2017). Cervantes (2013) in Samsudin et al., (2020) explains that student achievement is better on tasks given in authentic projects that draw subject knowledge to solve real-world problems so that STEM or STEAM education integrated with problem-based learning models can be said to be rational. In addition, the inquiry learning model also provides opportunities for students to take the initiative in learning and independence so that students can gain problem-solving skills through teamwork during the learning process (Zhai, 2019), thus the inquiry model can also be said to be rational when integrated with STEM or STEAM education.

Integration of STEM or STEAM Education

STEM or STEAM education in Indonesia is integrated into the education level. Science learning in Indonesia at the elementary school level is integrated into thematic learning, at the secondary school level it is integrated into science learning while at the senior high school level it is integrated into each subject, including physics, chemistry, and biology. At the tertiary level, students are prepared to have qualified provisions in applying learning in the field of science, so technology and engineering are needed in teaching their scientific disciplines.

Early childhood has a high curiosity about the surrounding environment (Putri, 2019). Science for early childhood is not just a collection of facts but involves activities about what happened, classifying information, predicting what will happen and testing predictions through guided activities, and formulating conclusions. NSTA (The National Science Teaching Association) revealed that learning science at the early childhood school level can facilitate various aspects of children's development including cognitive, language, art, physical motoric, social-emotional, even religious, and moral (Kementerian Pendidikan dan Kebudayaan RI, 2014).

Based on the findings of Debora & Pramono (2021), STEM integrated application of STEM with CAR can improve critical thinking skills and problem-solving in the topic of Weather (Science), making pictures (Technology), designing solutions to problems (Engineering), and generalizing and drawing conclusions (Mathematics). Amalia *et al*., (2021) also conducted a similar study by finding that at the early childhood school level, they had begun to integrate STEAM education into learning. STEAM education is a renewal of the results of the integration of STEM with additional Arts. In his research, STEAM education can increase students' creativity and independence.

STEM or STEAM education research in elementary schools is more developed on test questions (Syadiah & Hamdu, 2020; Hamdu et al., 2020) and 21st-century skills (Perdana et al., 2021; Nuraeni et al., 2020) in thematic learning integrated with STEM or STEAM education. At the secondary school level, its research implemented a lot of STEM integration with various learning models and media in science subjects. At the secondary school level, STEM or STEAM education is integrated with the application of various learning models, HOTS, 21st-century skills, and the development of performance appraisals. Based on the findings of Widarti *et al*., (2020) video-assisted STEM-project-based learning teaching materials can make it easier to learn chemistry and can improve 4C skills (communication, collaboration, critical thinking, problem-solving, and creativity). While at the vocational high level, STEM education is developed in the Engineering Design Process (EDP), 21st-century skills to equip students with work skills, independence, and careers (Nurtanto *et al*., 2020a).

STEM or STEAM education has been integrated into courses in a science study program (Rusydiyah *et al*., 2021) (Wardani *et al*., 2021), biophysics (Rosana *et al*., 2021) Technology, Engineering, and Mathematics, anatomy, and human physiology (Hidayati & Irmawati, 2019)technology, engineering, and mathematics (STEM, biology (Kurniati *et al*., 2020) and the manufacture of learning media (F. Ahmad *et al*., 2015). In the integration of STEM or STEAM education at all levels, the integrity of each scientific discipline or discipline that dominates can be identified.

STEM or STEAM Education Associated Theme

Critical thinking ability, scientific literacy, and learning outcomes are the dominant theme in STEM or STEAM education. This finding is in line with the literature review conducted by Ardwiyanti *et al*. (2021), namely STEM-related themes include mastery of concepts, scientific literacy, creativity, critical thinking skills, problem-solving, and learning activities.

Future STEM or STEAM Research Recommendations

Recommendations for future research related to these topics are proposed, including: (1) quantitative and qualitative research related to STEAM with the addition of Arts in STEM is proposed to determine the comprehensiveness of integration in science learning; (2) integrate STEM or STEAM holistically at every level of education; (3) conduct research and development of teaching materials and learning media based on technology as well as gamification and robotics; and (4) linking research themes that focus on 21st-century skills to prepare students in careers required by the International labour market.

Conclusion

The trend of STEM or STEAM education research in Indonesia is dominated by the most explored study topic in the last six years, namely learning strategies using experimental methods. Integrated learning models with STEM are project-based learning, problem-based learning, and inquiry. STEM education is the most widely applied in secondary schools in science subjects. Critical thinking skills, scientific literacy, and learning outcomes are the dominant themes related to STEM or STEAM education. Based on these findings, STEM education can facilitate skills in 21st-century learning.

Suggestion

It is necessary to conduct empirical research that begins to develop STEAM education holistically by using teaching materials or based on technology media as well as improving skills in 21st-century learning.

Limitation

The articles in the database, published from 2016 to 2021, including STEM education, STEAM education, and many articles related to STEM Education are still needed.

Conflict of Interest

The authors declare no potential conflicts of interest regarding this article's research, authorship, and/or publication.

Author Contributions

A. Z. Ilma – Study framework development, instrument development, manuscript writing, and data analysis. I. Wilujeng – visualization/presentation of data in text, manuscript writing, and manuscript submitting. A. Widowati – data input and correction. M. Nurtanto – typing, correction, and editing. N. Kholifah – data collecting, correction, and editing. All authors have read and agreed to the published version of the manuscript.

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