Mini review Improving teachers quality in STEM-based science teaching-learning in secondary school

by Syafrimen Syafril

Submission date: 29-Mar-2021 02:26PM (UTC+0700)
Submission ID: 1545236567
File name: in_STEM-based_science_teaching-learning_in_secondary_school.pdf (731.98K)
Word count: 5711
Character count: 33533

Journal of Physics: Conference Series

Mini review: Improving teachers' quality in STEM-based science teaching-learning in secondary school

Mini review: Improving teachers' quality in STEM-based science teaching-learning in secondary school

Syafrimen Syafril[1], Titik Rahayu[2], Sophia Fithri Al-Munawwarah[3], Ibdal Satar[4], Lilia Bt Halim[2], Nova Erlina Yaumas[1, 2], Agus Pahrudin[1]

[1]Universitas Islam Negeri Raden Intan Lampung, Jl. Letkol H. Endro Suratmin, Sukarame, Bandar lampung, Indonesia
[2]Faculty of Education, University Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia
[3]University of Muhammadiyah Lampung, Indonesia
[4]Department of Food Technology, Faculty of Industrial Technology University Ahmad Dahlan (UAD) 55166 Umbulharjo, Yogyakarta Indonesia

*Corresponding author: syafrimen@radenintan.ac,id

Abstract. The latest Approach in the teaching-learning process called "Science, Technology, Engineering and Mathematics" (STEM) has become the most recent trend in this decade. STEM aims not only to process and produce talents with expertise in education but also to function as a catalyst for economic growth and national development. However, there are still impending issues associated with the usage of STEM in secondary school, one of which is related to the quality of teachers. Previous research was used as a reference to discuss each of the problems analysed using NVIVO 12.0 software. The result showed that (i) an effective curriculum and (ii) increased motivation and teacher assistance in implementing STEM were the basis for improving teacher quality in STEM-based learning. STEM is useful in science learning, used in applying knowledge and skills for problem solving in everyday life. To improve teacher quality in the STEM-based teaching and learning process, teachers must master the conceptual model, design, implementation and evaluation of an integrated curriculum. Ongoing assistance to teachers to increase motivation in the STEM-based teaching and learning process also needs attention.
Keywords: effective curriculum, ongoing assistance, responsibility in the teaching-learning process, STEM-based instruction, teachers' quality.

1. Introduction

Sense of responsibility in the teaching-learning process is an essential quality of a teacher [1] . It comprises their awareness of required knowledge and skills, such as syllabus improvement, technology integration to refine and assist classroom instruction, conflict resolution, and keeping up positively strong connection between teacher and learners throughout the teaching-learning process [2]. This also extends to teachers' tactfulness in performing their educational duties [3] and to their carefulness in selecting appropriate learning media in accordance with school courses and learners' developmental stages [4]. Eventually, the effective teaching-learning process requires teachers to show high motivation to such an extent that it will similarly encourage their students to learn [5].

To develop expertise in 21st-century skills, teachers must have the capability to integrate STEM into the teaching-learning process, as the approach is expected to take the role as the primary learning medium in the future [6]. According to [7], 21st-century skills mainly involve the implementation of technology, creativity, critical thinking, interpersonal skills, and excellent social competence. STEM is a teaching-learning approach which blends four disciplines: sciences, technology, engineering, and mathematics [8] an embodiment of the skills every teacher has to know inside out in present-day education. The integration of these four disciplines in STEM will allow more relevant and more connected, meaningful learning [6].

STEM integration into secondary school education can improve students' motivation during classroom learning [9]. STEM has been observed to make teaching-learning process more appealing; stimulate imagination, productivity, observation, design, and engineering skills; and boost high-order thinking and psychomotor development [10]. Teaching-learning process can be successfully achieved if teachers have the required qualities for their education attempt [11], teachers who have quality will produce quality students [12], and STEM will help learners arrive at better comprehension if the approach is supplemented with qualified teachers [13] suggested that qualified teachers can improve the experience of teaching and learning in STEM namely mastering: (i) solid teaching graces, techniques, or line of attack; (ii) in-depth knowledge and preparation for lesson presentation; (iii) teachers' caring and open attitude towards both the students and the learning process; and (iv) reasonable capability for teachers.

Studies by [14–16], and discourse some coming issues in STEM-based instruction, particularly concerning teachers' quality in secondary school: first, teachers' scarce skill to integrate STEM addicted to classroom instruction; second, their relatively minimal knowledge on the nature of STEM; and third, the difficulty they face in generating meaningful and appropriate real-world connections in STEM-based instruction. These issues need to be further addressed to improve teachers' qualities in STEM implementation [7]. Qualified teachers now have become the staple of education as students' learning needs in STEM-related fields become more compelling [17]. Accordingly, they recommend that teachers' quality be better-quality substantially to guarantee successful STEM-based instruction. Improving teachers' quality involves linking STEM to real-world contexts [18]. A study by [19] found that the integration of STEM into teaching-learning process can help build teachers' self-confidence in STEM-based instruction. Teachers' quality and self-confidence in STEM-based instruction at school are still considered low and remain a challenge that has to be dealt with immediately [20–22]. The teacher's loss in integrating STEM learning is due to lack of pedagogical competence, and professional competence [14]. Additionally [15], assert that teachers' mastery of effective and efficient classroom instruction is to some extent not yet impressive. One of the difficulties faced by teachers in STEM learning in teaching and learning is when constructing relevant interactions [16].

According to [23], STEM-based learning has also fallen off in the United States. [15] has complained about little research that examines applicable principles and techniques for facilitating effective STEM-based instruction. [24] have defined three factors that contribute to lack of awareness among teachers regarding quality improvement in STEM-based instruction: (i) STEM is not properly understood; (ii) there is no clear vision about the nature of STEM-based instruction; some people even consider STEM irrelevant and of little importance; and (iii) there is still lack of partnership and synergy between related authorities to create well-established STEM teaching-learning framework. To arrangement with the issues associated with teachers' quality in STEM-based instruction, [25] advocates integrated, engaging and meaningful STEM-based learning by considering the following aspects: (i) project-based learning; (ii) flexible instructional time; (iii) consistent instruction with two or more teachers; (iv) orientation towards development of social skills; (v) comprehensive use of technology; and (vi) learning process can be implemented both inside and outside the classroom. STEM in secondary school will be successful if school subjects are integrated with STEM, engineering curriculum design, student cohorts, community involvement, and relevant practices [10].

One of the greatest issues is to create effective STEM learning [26], and this requires that experienced teachers' be of highest priority. Therefore, continual professional training and mentoring are absolutely necessary to provide qualified teachers. [27] assert that the need to teach, learn and master 21st-century skills is inevitable in almost every aspect of life today, including in school education. Qualified teachers are the answer to the issues and challenges described earlier.

2. Method

This article is a literature review to appearance at improving the quality of teachers in STEM learning in junior high schools. Data was extracted from scientific articles found from reputable scientific journals. International journals with Q1 reputation be present 27.4%, with Q2 reputations impressively as 8.06%, with Q3 reputations as much as 4.8%, with Q4 reputations greatly as 8.06% and international journals considerable as 25.8%. National journals with Sinta two (S2) repute were 3.2%, S3 with 9.6%, with S5 reputations were 4.8% and national journals were 8.06%. The articles were analyzed with the relief of NVIVO 12.0 software.

3. Result of Literature Review

3.1. Views of Teachers and Pre-Service Teachers on STEM

Five study literature synthesis was used to support this study, covering the study Radloff & Guzey *"Investigating Changes in Pra-service Teachers' Conceptions of STEM Education Following Video Analysis and Reflection"*; Pryor, Pryor, & Kang *"Teachers' thoughts on integrating STEM into social studies instruction: Beliefs, attitudes, and behavioral decisions"*; Kocakaya, Kotluk, & Karakoyun *"Pra-service Physics Teachers' Views on Designing and Developing Physics Digital Stories"*; Erdogan & Ayse Ciftci *"Investigating the Views of Pra-service Science Teachers on STEM Education Practices"*; Kuen-Yi & John *"Taiwanese Pra-service Teachers' Science, Technology, Engineering, and Mathematics Teaching Intention"*. However, to support these last five studies, researchers refer to other studies. Details are explained in the following sections.

There are similarities and differences in the five studies above, in Radloff & Selcen's study he studied how to optimize learning through integrated STEM. The findings show that seeing and reflecting integrated STEM practices can improve understanding of STEM concepts in teachers *Pre-service* on STEM integrated approaches, which represent a practical method for preserving the professional development of STEM teachers [26]. Almost in line with the study of Pryor, Pryor, and Kang in his study that formed the intention of teachers in integrating STEM content into the teaching of social studies. The findings of the study reveal that attitudes towards behaviour integrate STEM in learning, can form 15 beliefs, subjective norms are formed by five normative beliefs, and attitudes and norms predict behavioural intentions [19]. However, in addition to the similarities between the two studies, there are differences. In the study Radloff & Guzey studied in Pre-service teachers, while in the study Pryor, Pryor, & Kang studied teachers who have a lot of experience in teaching and learning.

Furthermore, the third of the five studies above were found to be almost identical, namely in the study of Kocakaya, Kotluk, & Karakoyun; Erdogan and Ayse Ciftci; and Yi Lin & John. In the study of Kocakaya, Kotluk, and Karakoyun, his study aimed to find out the views of physics teachers *Pre-service* on the effects of planning and developing digital physics stories (DST) in enhancing their 21st century capabilities. In his study, he found that they developed many of their 21st century skills; such as ICT (information and communication) technology, critical thinking, problem solving; planning, self-control, responsibility, production; communication, collaboration, and collaboration while creating their digital stories. Thus, designing and developing digital stories has a positive effect on the skills of physics teachers *Pre-service*, and improves many 21st century skills. In his study, it is suggested that researchers pay more attention to the use of ICT to succeed in 21st century skills[28].

Further, Erdogan and Ayse Ciftci's study tested the views of science teachers *Pre-service* on STEM educational practices. The findings show that science teachers *Pre-service* want to apply STEM education when they become teachers; they want to gain further knowledge about STEM education. In addition, science teachers *Pre-service* have submitted their views on the basic reasons, benefits and limitations of STEM education, and have made proposals for the development and dissemination of STEM education.

science teachers *Pre-service* learn about STEM education and how to apply it, with the help of STEM education practices conducted within the scope of this research. Therefore, *Pre-service* teachers who are future teachers need to be informed and trained about STEM education [27].

This is supported by the Yi Lin & John investigation, which examines the perceived behaviour of teachers *pre-service,* as well as attitudes towards behavioural intention among *pre-service* science teachers towards STEM education. The results of the investigation showed that higher perceived behavioural control and subjective norms were associated with stronger STEM teaching intentions. Positive attitudes and better knowledge were indirectly associated with higher subjective norms and perceived behavioural control, which resulted in stronger STEM teaching intentions. In addition, in the results of the study, gender did not affect the intention of teachers *pre-service* to adopt the STEM teaching approach. However, teachers *pre-service* who are in different fields tend to influence knowledge and behaviour control[29].

Findings from Serhat Kocakaya, Kotluk, & Karakoyun study that to develop 21st century skills required media such as ICT (information and communication technology) and teaching technique skills for teachers in learning to apply critical thinking, problem solving; planning, self-control, responsibility, production; communication, cooperation. Therefore, to design and develop digital-based physics stories have a positive effect on the skills of physics teachers *pre-service* as well as to improve 21st century skills. One of the suggestions to improve 21st century skills is through the application of STEM (Science, Technology, Engineering, and Mathematics) integrated teaching and learning practices in education. According to Shaughnessy (2013) that STEM education refers to problem solving that includes concepts and procedures from mathematics and science while combining teamwork and engineering design methods and using appropriate technology[28].

Radloff and Guzey's study emphasizes that teaching teachers must use an integrated STEM approach. He also stated that there is a challenge to 21st century skills, which is how to make learning effective through integrated STEM. Supported in the study of Pryor, Pryor, & Kang, integrating STEM content into social teaching and learning, can shape teachers' intentions in investigating beliefs in STEM. While Erdogan & Ayse Ciftci have given importance to the development of 21st century skills in every aspect of life. STEM education plays an important role in improving these skills and it is hoped that teachers will be able to organize the learning environment accordingly

Integrated STEM practices can enhance teachers' STEM concepts of integrated STEM approaches, representing a practical STEM method of professional teacher development *Pre-service* (Radloff & Guzey, Moore, Johnson, & Peters-Burton) in their study stated that integrated STEM is teaching and learning that provide content and practice of disciplinary knowledge including science and mathematics, through the integration of engineering practices and related technology design engineering. Here, the authors discuss six key components of each integrated STEM unit or activity, including: (a) relevant and interesting context (b) technical design challenges, (c) elements of failure and redesign, (d) mathematics or science-based real-world context, (e) student-centre teaching approaches, and (f) emphasis on teamwork and communication skills.

In the study Yi Lin & John is quite different from the other 4 studies. In their study concluding STEM teaching behaviour in teachers *Pre-service* Science and Technology in Taiwan, they evaluated positively on the impact of STEM teaching, and teachers *Pre-service* stated the need to have access and control of teaching resources needed to implement further STEM programs. This is the current challenge to provide a medium that can help teachers *Pre-service* in the future. Radloff & Guzey's study shows that in teaching and learning teachers *Pre-service* strive to integrate STEM. This is because students are often not interested in science and mathematics when taught separately without integration in STEM disciplines.

3.2. The Significance of STEM for Teachers

According to Mitts and Siekmann & Korbel, STEM is an acronym for the disciplines of science, technology, engineering and mathematics taught and applied in traditional and disciplined ways or through a multidisciplinary, interconnected and integrative approach. STEM teaching and learning can be delivered in a real-world context. According to Cavlazoglu & Stuessy, STEM integration in a real-world context can increase motivation, increase appeal, and improve student achievement in STEM learning effectively. To increase the effectiveness of teachers in STEM education can be done with STEM training. STEM education provides many benefits for various circles in education, as STEM education unites the disciplines of knowledge, leads to effective and quality learning, unites practice in real life, as well as stimulates individuals to think critically Yildirim and Altun ,. Supported by Akyildiz STEM education can provide relevant and practical learning experiences for all students. In addition, STEM education can increase interest in teaching and learning in the Corlu, Capraro, & Capraro classes [9]. In addition to STEM teachers are also useful for teachers *Pre-service*.

The benefits for teachers *Pre-service* STEM can enhance their imagination, hands-on skills, observation skills, design skills, engineering skills, and high-level thinking skills; helps with continuous knowledge with real-world knowledge, is more productive in increasing interest in lessons, and can help to develop the ability of teachers *Pre-service* to design projects. If that is achieved then the process of teaching and learning in the classroom is more fun Kasza & Slater. In line with the study of Yildirim & Sevi teachers *Pre-service* in his study stated that teaching and learning in STEM in the classroom conducted more fun, enable learning by living and doing, as well as be able to develop imagination, productivity and psychomotor skills.

3.3. Trend Issue: Teachers' Low Quality in STEM-based Teaching-Learning Process

Every developed country is trying to achieve an increasing number of competent graduates in sciences, technology, engineering and mathematics (STEM) [30]. STEM includes a group of disciplines considered crucial to master in the fields of education, industry, and many others. [31] defines STEM as (i) knowledge in sciences, technology, engineering, and mathematics; (ii) a form of human efforts; (iii) material, intellectual and cultural manifestations of the world; and (iv) emotional human ideas that contribute to education. Consequently, teachers have to expand their relevant knowledge, solid capability and practical experience in STEM-based instruction.

Beginning from mid-to school mid-level, studies show students' interest in STEM subjects is getting weaker [32]. This issue is primarily caused by considerable workload and minimum job satisfaction among teachers, which in turn leads to lack of performance [33]. Successful STEM-based instruction is strongly associated with teachers' quality since qualified teachers will be able to create effective learning through suitable instruction. Accordingly, teachers should encourage themselves to improve their knowledge and skills and become an inspiring facilitator throughout STEM-based teaching-learning process [23]. Teachers can improve their quality by building their own self-confidence [34], but it remains a serious challenge. [16]describe how teachers' quality in the classroom can be improved if teachers actively get engaged in their students' academic learning. As a qualified teacher, the teacher must also prepare content [35] and also teaching materials in learning[4]. Hence, the quality of teachers should be taken seriously to respond to challenges in the education world from time to time (continuous improvement).

The National Research [36] defines five characteristics of an effective teacher in STEM-based instruction, described in Figure 1 below:

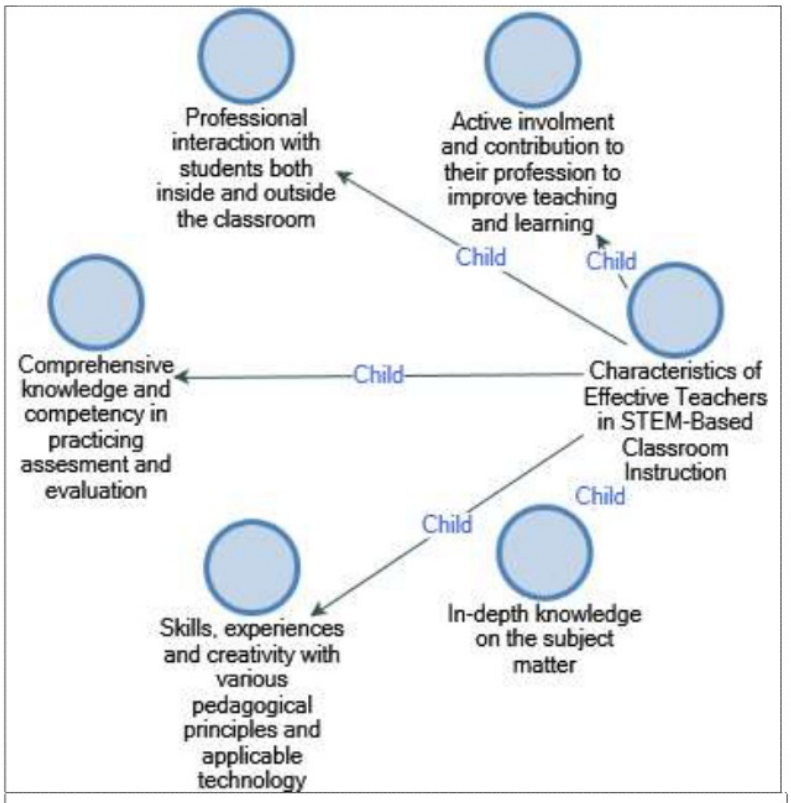

Figure 1. Characteristics of effective teacher in STEM-based instruction.

3.4. Strategies to Solve the Issues

Figure 2 rough idea the strategies for improving teachers' quality in STEM-based instruction.

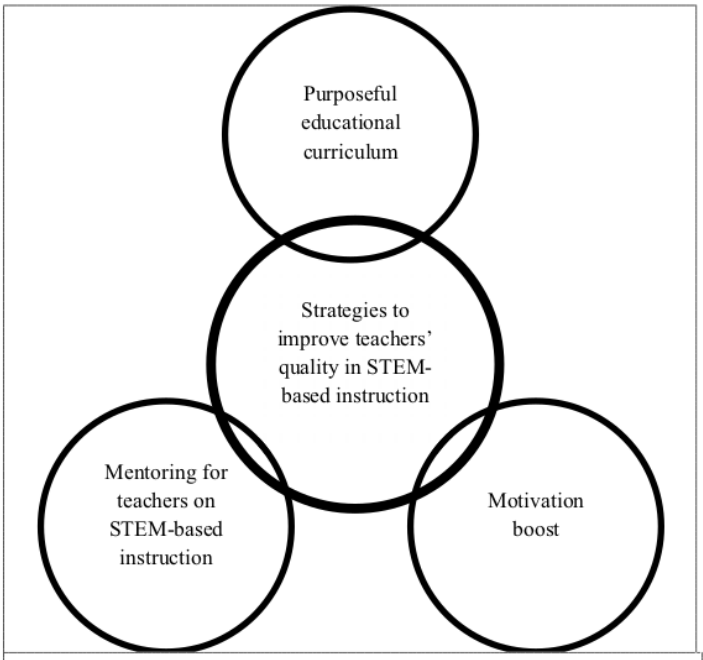

Figure 2. Strategies to improve teachers' quality in STEM-based instruction.

Syahali suggest that an effective educational curriculum will also lead to effective results in developing students' interest [37]. Likewise, it can help students exercise their critical problem solving skill [38]. A study by [39] recommends that STEM-integrated curriculum structure is started with mandatory courses, for example: (1) introduction to mathematics to strengthen students' basic algebra and calculation skills; (2) introduction to science to familiarize fundamental scientific questions and their answers, as well as to engage students into applications of scientific theories and comparative reasoning; (3) advanced sciences courses; and (4) curriculum-defined prerequisite integration to other relevant subjects. This is supported by a study by [6] that implementation of STEM integration into K-12 classrooms can be performed by building, executing, and evaluating the curriculum effectively. [36] however, in order to produce an integrated curriculum effectively it needs to be carefully designed so that a relevant curriculum integration model can be found in STEM teaching [36].

A study by [1] has proved the effectiveness of training and mentoring in STEM-based instruction to help teachers prepare themselves properly to run a STEM-based teaching-learning process. Mentoring programs play a crucial role for teachers, according to a study by [34], in which such programs will provide public education with qualified and professional teachers. Another study also found that STEM-based educational planning has proved useful for developing teachers' quality [40]. Also, mentoring programs can elevate pedagogic skills, which in turn will assist students in STEM learning [41].

3.5. STEM in Science Learning

In science learning, STEM is an alternative to train students to apply their knowledge by utilizing technology, so that students are trained to be literate in science and technology [42]. STEM is used for knowledge and science process skills for solving problems according to everyday life [43]. STEM-based learning requires students to become innovators, problem solvers, and inventors who are self-aware, technology conscious and able to think logically [44]. Also requires teachers and students to think critically [45].

The STEM approach is expected to produce good learning for students through the systematic integration of knowledge, concepts and skills [46]. STEM-based learning has the potential to improve the quality of learning and student motivation in learning science [47], improve conceptual mastery and develop a multitalented generation [48], increase learning effectiveness [49]. STEM-based learning can make lessons more meaningful for students [50]. Improve science learning because it creates opportunities to apply science [51]. Provide feedback on learning and provide a rapidly growing learning experience with a variety of knowledge and academic knowledge that students have [52]. STEM develops communication skills that refer to argumentation skills [53].

In STEM learning, it will help students' academic improvement, students can absorb learning gradually and better [54]. Teachers must be able to compile learning and determine strategies that help students learn well [55]. The teacher acts as a facilitator so that students can be actively involved in the lesson during the learning process [56]. Teaching materials are needed in the form of lesson plans, interactive books, videos, animation stimulation and practicum to support STEM learning [57].

STEM is suitable for use in science learning because it can encourage students to design, develop and utilize technology, hone cognitive, manipulative and affective and apply knowledge [58]. Through STEM learning, students do not just memorize concepts, but students can understand science concepts and their relation to everyday life [59]. Teachers can show students how the concepts, principles and techniques of STEM can be used in developing products, processes, and systems used in everyday life [60]. Students also have scientific and technological literacy from reading, writing, observing and doing science so that they can be used as provisions for living in society and solving problems [61]. The implementation of STEM-based science learning can increase student creativity in the form of fluent thinking skills, flexible thinking skills, original thinking skills, detailing skills, assessment skills, curiosity, imaginative nature, feeling challenged, courageous to take risks and respectful attitude [62].

4. Conclusion

To address forthcoming issues in 21st-century teaching and learning, teachers' quality in STEM-based instruction needs to be given serious attention. All difficult authorities have to provide their full support continuously to actualize successful STEM curriculum integration that will help mature responsible younger generation to further advance national education. To expand the quality of teachers in the STEM-based teaching and learning process, teachers must lead the conceptual model, design, carrying out and evaluation of the integrated curriculum. Continuing mentoring to teachers to growth motivation in the STEM-based teaching and learning process also need to be prominent.

Reference

[1]Maulana R, Helms-Lorenz M and Grift W V D 2015 A longitudinal study of induction on the acceleration of growth in teaching quality of beginning teachers through the eyes of their students *Teach. Teach. Educ.* **51** 25–245

[2]Syafrimen 2010 Pembinaan Modul Eq Untuk Latihan Kecerdasan Emosi Guru-Guru Di Malaysia

[3]Syafrimen, Ishak N M and Erlina N 2017 Six Ways to Develop Empathy of Educators *J. Eng. Appl. Sci.* **12** 1687–91

[4]Rahayu T, Syafril S, Wati W and Yuberti Y 2017 The Application of STAD- Cooperative Learning in Developing Integrated Science on Students Worksheet *J. Ilm. Pendidik. Fis. Al-Biruni* **6** 247
[5]Serafin C 2016 The Re conceptualization of Cooperative Learning in an Inquiryoriented Teaching *Procedia - Soc. Behav. Sci.* **217** 201–7
[6]Stohlmann M, Moore T J and Roehrig G H 2012 Considerations for Teaching Integrated STEM *J. Pre-College Eng. Educ. Res.* **2**
[7]Arsad N M, Osman K and Soh T M T 2011 More than a read-aloud: Preparing and inspiring early childhood teachers to develop our future scientist *Procedia Soc. Behav. Sci.* **15** 1470–4
[8]Ceylan S and Ozdilek Z 2015 Improving a Sample Lesson Plan for Secondary Science Courses within the STEM Education *Procedia - Soc. Behav. Sci.* **177** 223–8
[9]Corlu M S and M C M 2014 Introducing STEM education: Implications for educating our teachers for the age of innovation *Egit. ve Bilim* **39** 74–85
[10]Kasza P and Slater T F 2017 A Survey Of Best Practices And Key Learning Objectives For Successful Secondary School STEM Academy Setting *Contemp. Issues Educ. Res.* **10** 53–66
[11]Mclntyre K E M 2014 The evolution of social media from 1969 to 2013: A change in competition and a trend toward complementary, niche sites *J. Soc. Media Soc.* **3** 5–25
[12]Ishak N M, Hassan S N S and Syafrimen 2003 Quality Teachers Beget Quality Students: Inculcating Emotional Intelligence *In Paper presentes and published in proceedings ASAIHL Seminar on Quality Assurance in Higher Education Institutions: a Strive toward professionalism* (Jakarta, Indonesia: University of Indonesia)
[13]Aldemir J and Kermani H 2016 Integrated STEM curriculum: improving educational outcomes for Head Start children *Early Child Dev. Care*
[14]Eroglu S 2016 STEM Eğitimi Almış Fen Bilimleri Öğretmenlerinin STEM Temelli Ders Etkinlikleri Hakkındaki Görüşleri *Cilt J. Qual. Res. Educ.* **4** 43–67
[15]Pearson G 2017 National academies piece on integrated STEM National academies piece on integrated STEM *J. Educ. Res.* **110** 224–6
[16]Kyriakides L, Creemers B P M and Antoniou P 2009 Teacher behaviour and student outcomes: Suggestions for research on teacher training and professional development *Teach. Teach. Educ.* **25** 12–23
[17]Chiyaka E T, Kibirige J, Sithole A, Mccarthy P and Mupinga D M 2012 Comparative Analysis of Participation of Teachers of STEM and Non-STEM Subjects in Professional Development *J. Educ. Train. Stud.* **5**
[18]Ntemngwa C and Olier J S 2018 The Implementation of Integrated Science Technology, Engineering and Mathematics (STEM) Instruction using Robotics in the Middle School Science Classroom *Int. J. Educ. Math. Sci. Technol.* **6**
[19]Pryor B W, Pryor C R and Kang R 2015 eachers' thoughts on integrating STEM into social studies instruction: Beliefs, attitudes, and behavioral decisions *J. Soc. Stud. Res.*
[20]Atiles J T, Jones J L and Amderson J A 2013 More than a read-aloud: Preparing and inspiring early childhood teachers to develop our future scientist *Teach. Educ. Pract.* **26** 285–99
[21]Bagiati A and Evangelou D 2015 Engineering curriculum in the preschool classroom: The teacher's experience *Eur. Early Child. Educ. Res. J.* **23** 112–8
[22]Dobbs-Oates J and Robinson C 2012 Preschoolers' mathematic skills and behavior: Analysis of a national sample *School Psych. Rev.* **41** 371–86
[23]Chang Y and Park S w 2014 Exploring Students' Perspectives of College STEM : An Analysis of Course Rating Websites *Int. J. Teach. Learn. High. Educ.* **26** 90–101
[24]Brown R B, Joshua, Reardon K and Merril C 2011 Understanding STEM: Current Perceptions *Technol. Eng. Teach.* **7** 5–9

[25]Gardner M 2017 *Understanding Integrated STEM Science Instruction through Experiences of Teachers and Students* (Syracuse University. Retrieved from https://eric.ed.gov/?q=integrated+STEM&id=ED578410)
[26]Radolff J and Guzey S 2015 Investigating Preservice STEM Teacher Conceptions of STEM Education *J Sci Educ Technol*
[27]Erdogan I and Ciftci A 2017 Investigating the Views of Pre-Service Science Teachers on STEM Education Practices. *Int. J. Environ. Sci. Educ.* **12** 1055–65
[28]Kocakaya S, Kotluk N and Karakoyun F 2016 Pra-service Physics Teachers' Views on Designing and Developing Physics Digital Stories" *Digit. Educ.* **30**
[29]Lin K Y and Williams P J 2016 Taiwanese Preservice Teachers' Science, Technology, Engineering, and Mathematics Teaching Intention *Int. J. Sci. Math. Educ.* **14** 1021–36
[30]Hyunjoon Park J R B and Choi J 2018 Do single-sex schools enhance students' STEM (science, technology, engineering, and mathematics) outcomes? *Econ. Educ.* **62** 35–47
[31]Bybee 2010 Advancing STEM Education: A 2020 Vision *Technol. Eng. Teach.* **70** 30–5
[32]Hall C, Dickerson J, Batts D, Kauffmann P and Bosee M 2011 Are we missing opportunities to encourage interest in STEM fields?
[33]Moore C M 2012 The role of school environment in teacher dissatisfaction among US public school teachers *Sage Open* **2**
[34]Nolan A and Molla T 2017 Teacher confidence and professional capital *Teach. Teach. Educ.* **62** 10–8
[35]Pahrudin A, Syafril S and Sada H J 2018 Learning Content of Islamic Education Based on Multikultural in Senior High School in Bandar Lampung *Al-Tadzkiyyah J. Pendidik. Islam* **9** 81
[36]Timms M, Moyle K, Weldon P and P M 2018 Challenges In Stem Learning In Australian Schools *Aust. Counc. Educ. Res.*
[37]Shahali H, Jaggesar A and Yarlagadda P K D V 2017 Recent Advances in Manufacturing and Surface Modification of Titanium Orthopaedic Applications *Procedia Eng.* **174** 1067–76
[38]Kristin Lesseig D S and N T H 2017 Jumping on the STEM bandwagon: How middle grades students and teachers can benefit from STEM experiences *Middle Sch. J.* **48** 15–24
[39]Sturtz N 2018 Success in the STEM Curricula **21**
[40]Avery Z K and Reeve E M 2013 Developing Effective STEM Professional Development Programs *J. Technol. Educ.* **25**
[41]Singer J e, Ross J M and Jakso-Lee Y 2016 Professional Development for the Integration of Engineering in High School STEM Classrooms *J. Pre-College Eng. Educ. Res.* **6** 3
[42]Yuliati Y and Saputra D S 2019 Pembelajaran Sains Di Era Revolusi Industri 4.0 *J. cakrawala pendas* **5** 167–71
[43]Siswanto J 2018 Keefektifan Pembelajaran Fisika dengan Pendekatan STEM untuk Meningkatkan Kreativitas Mahasiswa *J. Penelit. Pembelajaran Fis.* **9** 133–7
[44]Susanti L Y, Hasanah R and Khirzin M H 2018 Penerapan Media Pembelajaran Kimia Berbasis Science, Technology, Engineering, and Mathematics (STEM) untuk Meningkatkan Hasil Belajar Siswa SMA/SMK pada Materi Reaksi Redoks *J. Pendidik. Sains* **06** 32–40
[45]Santoso S H and Mosik M 2019 Kefektifan LKS Berbasis STEM (Science , Technology , Engineering and Mathematic) untuk Melatih Keterampilan Berpikir Kritis Siswa pada Pembelajaran Fisika SMA *Unnes Phys. Educ. J.* **8**
[46]Afriana J, Permanasari A and Fitriani A 2016 Penerapan project based learning terintegrasi STEM untuk meningkatkan literasi sains siswa ditinjau dari gender *J. Inov. Pendidik. IPA* **2** 202
[47]Hani R and Suwarma I R 2018 Profil Mtivasi Belajar IPA Siswa Sekolah menengah Pertama dalam Pembelajaran IPA Berbasis STEM *J. Wahana Pendidik. Fis.* **3** 62–8
[48]Nurbaya C B, Yuliati L and Sutopo 2019 Penguasaan Konsep Fluida Dinamis Siswa melalui

Pembelajaran Berbasis Inkuiri dalam STEM *J. Pendidik. Teor. Penelit. dan Pengemb.* **4** 510–5
[49]Tseng K H, Chang C C, Lou S J and Chen W P 2013 Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PjBL) environment *Int. J. Technol. Des. Educ.* **23** 87–102
[50]Chonkaew P, Sukhummek B and Faikhamta C 2013 Development of Analytical Thinking Ability and Attitudes towards Science Learning of Grade-11 Students through Science Technology Engineering and Mathematics (STEM Education) in the Study of Stoichiometry Patcharee *Chem. Educ. Res. Pract.* **6** 1–25
[51]Kelley T R and Knowles J G 2016 A conceptual framework for integrated STEM education *Int. J. STEM Educ.* **3**
[52]Butler A C, Marsh E J, Slavinsky J P and Baraniuk R G 2014 Integrating Cognitive Science and Technology Improves Learning in a STEM Classroom *Educ. Psycology Rev.* **26** 331–40
[53]Paramita A, Dasna I W and Yahmin Y 2019 Kajian Pustaka: Integrasi Stem Untuk Keterampilan Argumentasi Dalam Pembelajaran Sains *J-PEK (Jurnal Pembelajaran Kim.* **4** 92–9
[54]Wahono B, Lin P and Chang C 2020 Evidence of STEM enactment effectiveness in Asian student learning outcomes *Int. J. STEM Educ.* **7** 1–18
[55]Wright K B 2019 Improvement Science as a Promising Alternative to Barriers in Improving STEM Teacher Quality through Professional Development STEM Teacher Quality through Professional Development *Clear. House A J. Educ. Strateg. Issues Ideas* 1–8
[56]Irekpita M, Mohd S, Samsudin A and Yakob N 2020 Effect of design thinking approach on students ' achievement in some selected physics concepts in the context of STEM learning *Int. J. Technol. Des. Educ.* 1–28
[57]Widayanti, Abdurrahman and Suyatna A 2019 Future Physics Learning Materials Based on STEM Education : Analysis of Teachers and Students Perceptions *J. Phys. Conf. Ser.* **1155** 1–10
[58]Sumira T and Aprida 2020 STEM Education: Inovasi dalam Pembelajaran Sains *Pros. Semin. Nas. Pendidik. Progr. Pascasarj. Univ. pgri palembang* 815–27
[59]Yulia S R and Ramli R 2019 AnalisisKebutuhan Pengembangan Handout Berbasis STEM Terhadap Pembelajaran Fisika dalam Menghadapi Era Revolusi Industri 4 . 0 *J. Penelit. Pembelajaran Fis.* **5** 42–8
[60]Subekti H, Taufiq M, Susilo H, Ibrohim and Suwono H 2018 Mengembangkan Literasi Informasi Melalui Belajar Berbasis Kehidupan Terintegrasi Stem Untuk Menyiapkan Calon Guru Sains Dalam Menghadapi Era Revolusi Idustri 4.0: Revieu Literatur *Educ. Hum. Dev. J.* **3** 81–90
[61]Wisnu Wibowo I G A 2018 Peningkatan Keterampilan Ilmiah Peserta Didik dalam Pembelajaran Fisika Melalui Penerapan Pendekatan STEM dan E-Learning *J. Educ. Action Res.* **2** 315
[62]Singgih S, Dewantari N and Suryandari 2018 STEM dalam Pembeljaran IPA di Era Revolusi Industri 4.0 *Indones. J. Nat. Sci. Educ.* **03** 299–304

Mini review Improving teachers quality in STEM-based science teaching-learning in secondary school

ORIGINALITY REPORT

14%	13%	8%	8%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.researchgate.net Internet Source	4%
2	Dian Purnamasari, Ashadi, Suryadi Budi Utomo. "Analysis of STEM-PBL based e-module needs to improve students' critical-thinking skills", Journal of Physics: Conference Series, 2020 Publication	3%
3	Submitted to Universiti Teknologi MARA Student Paper	2%
4	files.eric.ed.gov Internet Source	2%
5	link.springer.com Internet Source	1%
6	www.diva-portal.org Internet Source	1%
7	Jeffrey Radloff, Selcen Guzey. "Investigating Changes in Preservice Teachers' Conceptions of STEM Education Following Video Analysis	1%

and Reflection", School Science and Mathematics, 2017

Publication

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		