Dominant Instructional Practices and their Challenges of Implementation in Integrated STEM Education: A Systematic Review with the Way Forward

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Abstract

STEM education plays an important role in 21st-century learning. It is believed that the use of appropriate and effective instructional practices in STEM education can raise the students' interest and academic achievement in science, technology, engineering and mathematics. Thus, this study intended to investigate the most utilized strategy among various types of instructional practices used for integrated STEM education in secondary school to promote teachers and students' interest. It employs a systematic review of 10 selected articles from the year 2011 to 2018. Four most visited search engines were used to search for related articles published. The search process was executed in two phases. A total of 11,342 papers were obtained from the first phase searching result in which after series of screenings, the result was narrowed to 10 articles in the second phase. In the second phase, these 10 articles were analyzed based on the challenges encountered by teachers in implementing the STEM approach and various types of instructional practices used for integrated STEM education. The result of the analysis revealed that the most challenges encountered by teachers in implementing the STEM approach were the negative perception related to time, resources and knowledge constraints. Moreover, the findings indicate that the dominant instructional practice preferably used in secondary schools integrated STEM education was project-based learning (PjBL) where the combination of four disciplines can be integrated into an authentic problem or project. Suggestions made focus on a variety of approaches with detailed content and lesson plan to guide implementation of integrated STEM education.

Keywords: Integrated STEM education; STEM in secondary schools; Constructivist approach; Systematic review; Instructional practices

Introduction

Workplaces of this century require competent human resource in science, mathematics, engineering and technology (STEM). Therefore, it is very essential for school curriculum nowadays to integrate all of these fields in education. Science, Technology, Engineering and Mathematics (STEM) is believed not only to enhance the students' interest and academic achievement but also a tool for achieving economic and global prowess for the nation (Putra,

2012). If the science, technology, engineering and mathematics are taught separately, it is known as "silos" (S-T-E-M) while an integrated STEM is an instructional approach which enables students of all four disciplines to gain more experiences and skills to settle the problem arise while learning through appropriate instruction practice (Thibaut, Knipprath, Dehaene, & Depaepe, 2018). Integrated STEM education is the best approach compared to "silos" in 21st-century learning.

It is believed that STEM education has the potential to increase the involvement of the students in STEM-related jobs (Stohlmann, Moore, & Roehrig, 2012). Besides, STEM education also helps to raise the literacy of people in science and technology around the world. Integrated STEM education has a positive effect on student attitudes and interests in school (Tseng, Chang, Lou, & Chen, 2013) and motivation toward learning (Gutherie, Wigfield, & VonSecker, 2000). Moreover, the students' motivation to learn was influenced by the enjoyment of learning towards the subject (Al-Shara, 2015 & Talib et al., 2018). The improvement of higher-order thinking skills and technological literacy can be seen through an integrated STEM education making them as good problem solvers, inventors and innovators (Stohlmann et al., 2012). Chew (2014) mentioned that students who master all four disciplines in STEM education have higher capabilities to solve the problems, identify, implement and integrate all the concepts and can be a good innovator to the complex issues.

In the Malaysian context, the educational practices in learning sciences are based on factual knowledge where the students do not understand science in nature. Yunos, Ismail and Raper (2004) mentioned that teachers lack the constructivist approach and prefer to modify this approach with their understandings. Teachers' mindset toward integrated STEM approach is one of the factors causing them to hesitate to implement the various types of constructivist approach in their teaching session (Nadelson & Seifert, 2017).

Problem Statement

In Malaysia, the involvement of students in science and engineering field at secondary schools and tertiary education has been declining tremendously years ago as reported by (Wilson & Mack, 2014). The occurrence of the decreasing enrollment of science students is not only observed in Malaysia but also at international level. According to Heong, Yunos and Hassan (2011), there is no relationship between gender and higher-order thinking skills in middle school but the gender becomes a factor at tertiary education. Seong (2016) stated that male students prefer to choose careers related to physics, engineering or mathematics while female students tend to choose careers associated with life sciences or health-related fields like biology, microbiology, biochemistry or biotechnology. Even though female students perform better in test or project related to STEM education, they tend to lose their interest to participate in course and careers in the STEM field (Reinking & Martin, 2018)

Mullis, Martin, Foy, and Hooper (2016), state that the Trends in International Mathematics and Science Study (TIMSS) 2015 revealed that Malaysian students show better improvement in science and mathematics for grade 8. However, the target to be in higher ranking and international average benchmarking has still not been achieved. TIMSS 2011 reported that Malaysian students are weak in higher-order thinking skills where they could not recognize the science fact and has low achievement in reasoning skills (Martin, Mullis, Foy & Stanco, 2012). Programme for International Student Assessment (PISA) also reported that Malaysia still has not achieved the average score targeted by every country. The weakness has been observed in mastering the

concept, skills, applications and problem-solving in mathematics, science and literacy (OECD, 2019)

Although STEM education has been implemented for many years, many teachers claimed that they were less prepared to conduct STEM application in the classroom (El-Deghaidy & Mansour, 2015). Teachers also do not have an idea about T (Technology) in the STEM education and how to combine this T with Science, Engineering and Mathematics (Ashgar, Ellington, Rice, Johnson, & Prime, 2012). Moreover, conducting an integrated STEM education required high cost and time-consuming (Hardy, 2001; Nadelson & Seifert, 2017).

Implementation of the STEM approach required students to know the basic understanding and strong concept of each field of knowledge. The lack of knowledge and skills causes hardship for students in applying many types of STEM education approaches. According to Nadelson and Seifert (2017), the implementation of integrated STEM education involves ill-structured problems with multiple solutions adding with deep knowledge in all disciplines. Problem and project-based learning associated with inquiry are some of the approaches of integrated STEM applied in schools.

Research Questions

The purpose of this study was to determine various types of instructional practices used for integrated STEM education in secondary school to promote teachers and students' interest in STEM subjects. Besides, this study intended to obtain an overview of some challenges faced by the teachers to conduct integrated STEM approaches in their classroom. The specific questions addressed in this systematic review are:

i. What is the dominant instructional practice used in integrated STEM in secondary school?

ii. What are the challenges faced by the teachers employing an integrated STEM education in their classroom?

Methodology and Analysis

Research Method and Data Collection Techniques

This study employs a systematic review which answers the aforementioned defined research question by collecting and summarising all empirical evidence that fits pre-specified eligibility criteria. It involves the following five steps, i.e. framing the question, identifying relevant publications, assessing study quality, summarizing the evidence and interpreting the findings (Khan, Kunz & Kleijnen, 2003).

Only articles published from 2000 to 2018 focusing on integrated STEM education are considered. Moreover, most of the selected articles were obtained from Science Direct, search engines like ERIC, SpringerLink and Google Scholar. During the review, few keywords were used to search related information including "STEM", "Instructional Practices + Integrated STEM", "Instructional Approach + Integrated", "Teaching + Integrated STEM Education", "Integration STEM Education + Approach" and "Multidisciplinary STEM + secondary schools". While searching for these keywords, the emphasis was given to STEM education in secondary school.

Phases of Studies and Data Analysis

In the first phase of the search, a total of 11,342 articles were obtained from the first search result. Many findings and recommendations of those articles' search-result were out-dated and are addressed by recent articles published. Thus, the search was later narrowed down to articles published between 2011 and 2018. This marks the second phase of the search quest.

In the second phase, about 267 articles were obtained from the search results. The articles were reduced to 136 by considering the title of the papers. Furthermore, the selection process continues and the search-result was narrowed to 27 by screening out the articles for which their findings did not answer the research problem(s). Many abstract of the articles were found not reflecting the content in the research. Finally, a total of ten articles were selected for the analysis. while eight articles were used to analyze the variety of instructional practices applied in integrated STEM education, three articles are used to analyze teachers' attitude towards integrated STEM education in the classroom. The purpose of this selection was to get an overview of the latest instructional practices used in integrated STEM education. In these selections, only one article retrieved contained both instructional strategies and challenges faced by the teachers. The other articles were excluded since they did not provide much information related to the objective of the study. The articles were analyzed and summarized according to the research questions and instructional practices represented by Table 1 and Table 2 below.

Table 1
Analysis of Instructional Practices

Studies	Integration of STEM content	Problem-Based Learning (PBL)	Project-Based Learning (PjBL)	Design-Based Learning (DBL)	Inquiry-Based Learning (IBL)	Cooperative Learning (COL)	Technology-based Learning
Rasul, Halim and Iksan (2016)			/				
Thibaut et al. (2018)	/	/	/	/	/	/	
Hui, Moore, Roehrig, and Mi (2011)	/	/	/				
Jehlicka and Rejsek (2018)							/
Capraro (2015)			/				
Han, Capraro and Margaret (2014)			/				
Ntemngwa and Oliver (2018)							/
Ceylan and Ozdilek (2014)					/		

Table 2
Analysis of Teachers' Challenge Towards Integrated STEM Education

Studies	Resources/ Materials	Negative perception	Teachers' comfort level	Time schedule	Unfamiliar with how to conduct integrated STEM	Collaboration between office mate
Stohlmann, Moore, and Roehrig (2012)	/		/	/		
Capraro (2015)		/				
Wang, Moore, Roehrig and Park (2011)		/			/	/

Results and Discussion

This section discusses findings in response to Research Question (RQ) 1 and RQ2. Thus, the discussion is represented in two subsections including "Instructional Practices in Integrated STEM Education" and "Teachers' Challenge Towards Integrated STEM Education".

Instructional Practices in Integrated STEM Education

The analysis of data as reflected in Table 3 revealed that there were more than one instruments used for data collection in one article. The frequency of the use of questionnaire instruments was 7.69% (n=1), teacher interview 23.1% (n=3), test scores 30.77% (n=3), observation 30.77% (n=4) followed by demonstration 7.69% (n=1). It indicates that the observation and test scores were mostly used instruments for data collection while questionnaires and demonstration were the least instruments used in selected articles.

Table 3
Research Instruments Used for Data Collection from the Reviewed Articles (N=12)

Research Instrument	2011	2012	2014	2015	2016	2018	Total
Questionnaire					1		1
Teacher Interview	1			1		1	3
Test Score			1	1		1	3
Observation	1	1		1		1	4
Demonstration						1	1

From the summary Table 1, it is shown that project-based learning was a dominant instructional practice used in integrated STEM education. In project-based learning, students have more opportunities to conduct and handle the task given compared to the problem – based learning where the students were provided with the research questions and the context of the problem (Han, Capraro, & Capraro, 2016). STEM Project-Based Learning (PjBL) was an instructional approach developed using an engineering principle to enhance students' problem-solving skills, communication skills and the understanding the contents of all disciplines of STEM. The combination of previous and recent knowledge can be applied through STEM PjBL. This approach represents the reformed curriculum where the integration of ill-defined tasks, students' self-directed learning, teachers' facilitation, textbooks and performance based-assessment/evaluation can be seen. The application of constructivist approach and cooperative and collaborative learning were part of STEM PjBL (Clark & Ernst, 2007). This is one of the reasons why STEM PjBL became a preferable approach used in the integration of STEM education.

According to Rasul, Halim, and Iksan (2016), the students' 21st-century skills increased by 4.9 % through the PjBL approach with many *hands on-minds* which are initiated by the question and ending with the solutions. Thibaut et al. (2018) mentioned that the integration of STEM content and problem-centred learning are influenced by the social interaction of peer teachers (social context) and management context indicated as in Table 4. While for other approaches such as inquiry-based, design-based learning and problem-centred learning, the implementation was influenced by management support and involvement at middle school. For cooperative learning, organizational context such as sufficient teaching time and co-teaching influenced the teachers to conduct this approach in their classroom.

Table 4
Major Findings on Instructional Practices (Part 1)

Author	Topic	Major Findings
Rasul, Halim, and Iksan (2016)	Using STEM Integrated Approach to Nurture Students' Interest and 21ST Century Skills	The PjBL conducted in STEM Bitara Programme applied with many hands on-minds on activities initiated by the question and ending with the solutions. Additional information was searched via the Internet to enhance the extra idea needed in implementing the project. The students' skill of the 21st century was increased by 4.9 % through the PjBL approach.
Thibaut, Knipprath, Dehaene, and Depaepe (2018)	The influence of teachers' attitudes and school context on instructional practices in integrated STEM education	Integration of STEM content and problem-centred learning were influenced by the social interaction of peer teachers (social context) and management context. For inquiry-based learning, design-based learning and problem-centred learning, management support and involvement influenced these implementations at middle school. The cooperative learning, organizational context (sufficient teaching time and co-teaching) influenced the teachers to conduct this approach in the classroom.
Jehlička and Rejsek (2018)	A multidisciplinary approach to teaching mathematics and Information and Communication Technology (ICT) (2017)	The use of a specific example of mathematic calculation in the integration ICT was conducted to increase the students' interest in STEM education. This approach helps the students to store numbers in computers memories with number notation in many numerical systems. The application of ICT in mathematics was to integrate the technology into mathematics.
Han, Capraro, and Capraro (2016)	How Science, Technology, Engineering and Mathematics (STEM) Project-Based Learning (PBL) affects high, middle and low achievers differently: the impact of student factors on achievement	After attending a few months of STEM education training, this teacher implemented STEM PjBL in her classroom and found that low achiever students show a higher increase in mathematic achievement and this PBL help to reduce the gap of intermediate and higher achiever students in mathematics subject.
Ntemngwa and Oliver (2018)	The Implementation of Integrated Science Technology, Engineering and Mathematics (STEM) Instruction using Robotics in the Middle School Science Classroom.	One of the teachers conduct the robotics project in a classroom using her prior knowledge in robotic and integrate this idea and knowledge in her lesson plan. This groups of the teachers found that the collaboration with one of the technology teachers who was an expert in this robotic knowledge assist them to implement the STEM approach successfully. Many students show interest in asserting questions about robotics.
Ceylan and Ozdilek (2015)	Improving a Sample Lesson Plan for Secondary Sciences Courses within the STEM Education	The inquiry-based approach helps the students to integrate the acid-base content in engineering, technology and mathematics. These can be seen when the students were required by the teacher to conduct an acid bases experiment, watching animation related to the topics given at the computer laboratory and asked to create a slow-motion, doing a calculation and making a pH graph and building a pH metre in

engineering disciplines. Then, the students use their skills to create a simple project on how to protect the living organism from acid rain effects.

Han, Yalvac, Capraro, and Capraro (2015)(Table 5) stated that the PjBL and PBL strategies implemented by the teachers in their classroom help them to explain the content of the subject by relating with the real-life problem to find a better solution faced by the society. The results of the study conducted by Capraro (2015) revealed that five of the teachers has different perspectives on the implementation of PjBL STEM in their classroom. A few of them expressed that they could enhance their lesson plan by implementing STEM approach where they can gain a big idea on how to integrate the four subjects in their classroom. One of the teachers have a sceptical view and only implements PjBL to higher achiever students. Most of them agreed that the implementation of STEM approach depends on their students' readiness. Hans, Capraro, and Margaret (2014), stated that a teacher who implemented STEM PjBL in her classroom found that low achiever students show a higher increase in mathematic achievement and this PjBL help to reduce the gap of intermediate and higher achiever students in mathematics subject.

Table 5
Major Findings on Instructional Practices (Part 2)

Author	Topic	Major Findings
Wang, Moore, Roehrig, and Park (2011)	STEM Integration: Teachers' Perceptions and Practice	From an interview conducted to the three teachers; 1st teacher prefers to choose integrated STEM starts with engineering disciplines combining with problem-based learning for her students to solve the problem in mathematics subject she taught. 2nd teacher prefers to choose integration STEM starts with engineering disciplines in her science classroom. 3rd teacher prefers to choose project-based learning which was an adult-sized cardboard chair for two months period completion. She wanted to relate this structure with the human skeleton.
Han, Yalvac, Capraro, and Capraro (2015)	In services teachers' implementation and understanding of STEM project-based learning	All five teachers stated that they include a lesson plan included two or more areas. All of the teachers being interview stated that they recognize their role from a guide to a facilitator in STEM PBL activities. Five teachers had been interviewed and observed with the implementation of PBL in science and mathematics class. They gave different understandings and enactment of STEM PBLs during the learning session. Case 1: John was a mathematics teacher designed a lesson plan of PBL and only conducted this approach to a higher achiever student. He found that this group of students can design and solve the mathematics solution using a problem given related to all four disciplines. Case 2: Chira was a mathematics teacher believing that the STEM approach had a positive impact on conceptual understanding of mathematics contents. By implementing this approach with a lesson plan, she conducted a formative assessment by recording and

giving a grade to their students' work. The evaluation and product outcome was divided into individual and group grade.

Case 3: Susan was a mathematics teacher and eager to conduct STEM PBL in her classroom. The approach of this teacher was called "thinking outside of the quadrilaterals" and combine this activity with the use of video clip. She believed that this approach helps her to attract their students' interest and improve their understanding of the mathematic concept.

Case 4: Linda was a science teacher and design her lesson plan by combining environmental sciences, mathematics, English and social studies. She said that STEM PBL show that the teachers became expert in doing a lesson plan and had a big picture for teachers to conduct and relate many subjects in the teaching session. She evaluates her students' readiness on daily reports individually and poster groups.

Case 5: Robert believed that STEM PBL are associated with students' future income. Robert preferred their students work.

There are other instructional approaches which can be conducted in the classroom through integrated STEM education such as Problem–Based Learning (PBL) and Inquiry-Based Learning (IBL). According to Tseng et al. (2013), PBL is an instructional approach where a specific procedure was provided to the students before they engaged in ill-structured problems to find a possible solution in their groups. The findings will be shared with the other groups and a deep discussion will be conducted to find a better and correct solution. All the skills obtained from this approach help them cultivate their interest towards STEM subject (Ashgar et al., 2012).

Inquiry-Based Learning (IBL) in STEM education required active participation and self–regulation towards knowledge. IBL conducted in a study by Ceylan and Ozdilek (2014) revealed that there was a positive effect of the students' understanding of four disciplines of knowledge after IBL was conducted in acid and bases experiments. This study was aligned with the results obtained by Becker and Park (2011) showing that IBL makes the students become a good interdisciplinary thinker. The design-based learning required students to formulate a hypothesis for real-world problems, designing the process and reflection of the chosen solutions. This approach helps to build student to become a more creative and innovative person.

Teachers' Challenge Towards Integrated STEM Education

From the summary in Table 6, it is shown that teachers face many challenges to conduct the teaching and learning session using an integrated STEM education approaches. Capraro (2015) mentioned that the negative perceptions of teachers towards the implementation of integrated STEM education include more time spending on planning and conducting the classroom. Thibaut et al. (2018) found that the perceptions of teachers varied among the different instructional approaches.

Table 6
Analysis of Teachers' Challenge Towards Integrated STEM Education

Author	Topic	Major Findings

Stohlmann, Moore, and Roehrig (2012)	Considerations for Teaching Integrated STEM Education	a) Time schedule Teachers found that they do not know exact time how long lessons would last and the directions of a lesson plan using integrated. STEM education b) Teachers' comfort level Some teachers hesitated to implement STEM education and only want to teach their subject. They did not want to invest much time on STEM activities that took a long time. to implement c) Material/resources Teachers found that they need more room space to keep students' material and projects. Internet website, applets, design programs, dynamic and robotic software and calculators need to be provided in STEM integrated classroom.
Han, et al. (2015)	In-service Teachers' Implementation and Understanding of STEM project-based Learning	The negative perception of teachers towards the implementation of integrated STEM included the level of achievement of the students. Some of the teachers said that the higher achiever students can achieve the aim of integrated STEM education where they can settle the problems given until the end of the task.
Wang, Moore, Roehrig, and Park (2011)	STEM Integration: Teachers' Perceptions and Practice	Teachers need to collaborate with other teachers especially those teaching technology for implementation in the classroom. If not, it was difficult to handle an integrated STEM lesson in the classroom. Teachers are quite unfamiliar with the real-world implementation of integrated STEM education and think that good STEM curriculum is really needed by the teachers.

Teachers' attitude and perceptions are strongly correlated with Inquiry-based Learning (IBL), Design-based Learning (DBL) and Cooperative Learning (CL). The weak correlation between teachers' attitude and perceptions with integration and Problem–based Learning (PBL) was due to its multidisciplinary nature and the use of authentic problems. The positive correlation between teachers in middle schools with their colleagues from a different subject background influenced their instructional approaches in integrated STEM education (Stohlmann et al., 2012).

The support gain from peer also helps the teachers to implement cooperative approach successfully (Depaz & Moni, 2008). The budget constraints of the resources also affect teachers' perception to conduct a cooperative approach. Teachers also face some challenges hindering them to conduct integrate STEM education approach. Wang et al. (2011) mentioned that teachers found it difficult for them to apply technology in the integrate STEM classroom. They always believed the students should be engaged in technology to enhance their skills in STEM education.

Conclusion

This study is a general review of the idea of instructional practices of integrated STEM education. Most of the article focusing on the implementations outside Malaysia. The results reveal that integrated STEM education teachers were predominantly using IBL, PBL and PjBL as practices

for instructional delivery in secondary school. Project-based learning (PjBL) was a dominant approach for the teachers to conduct in the classroom. The students were capable to discuss and solve the problems given in all disciplines where they can see the importance and connection of all subjects. Some of the challenges faced by the teachers in employing an integrated STEM education in their classroom include negative perceptions which are related to time, resources and knowledge constraints. Hence, teachers need appropriate training in order to become cumbersome with the real-life application of instruction content in an integrated STEM educational system.

Limitation

In this systematic review, the articles selected including discussions on the implementation of instructional approaches of integrated STEM education in secondary school. Most of the articles selected did not describe the lesson plan of the instructional approaches where a brief explanation is given focusing on types of approaches used. Therefore, it could not help to guide the teachers on how to conduct their integrated STEM classroom in a proper way.

Recommendation

Integrated STEM education has the ability to promote students' involvement in the STEM field. Therefore, a thorough study should be focused on a variety of approaches suitable for the teachers to conduct during the learning session. The ministry of education should develop more program focusing on technology skills that should be possessed by the teachers. A detailed content and lesson plan which describes the implementation of integrated STEM education should be developed in primary and secondary schools. This is because the Standard Curriculum for Primary Schools (KSSR) and Standard Curriculum for Secondary Schools (KSSM) emphasize on the higher-order thinking skills such as applying, analyzing, evaluating and creating. All of these skills can be developed through the implementation of instructional approaches in integrated STEM education.

In future, further study should be considered on how to raise teachers' confidence level towards a better approach of integrated STEM education. Teachers need to update themselves in technology knowledge so that it will boost their confidence level to apply this approach.

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Appendix A

Major Findings on Instructional Practices

Author	Topic	Major Findings
Rasul, Halim and Iksan (2016)	Using STEM Integrated Approach to Nurture Students' Interest and 21ST Century Skills	The PjBL conducted in STEM Bitara Programme applied with many hands on-minds on activities initiated by the question and ending with the solutions. Additional information was searched via the internet to enhance the extra idea needed in implementing the project. The students' skill of the 21st century was increased by 4.9 % through the PjBL approach.
Thibaut, Knipprath, Dehaene and Depaepe (2018)	The influence of teachers' attitudes and school context on instructional practices in integrated STEM education	Integration of STEM content and problem-centred learning were influenced by the social interaction of peer teachers (social context) and management context. For inquiry-based, design-based learning and problem-centred learning, management support and involvement were influenced these implementations at middle school. for cooperative learning, organizational context (sufficient teaching time and co-teaching) influenced the teachers to conduct this approach in the classroom.
Wang, Moore, Roehrig, and Park (2011)	STEM Integration: Teachers' Perceptions and Practice	From an interview conducted to the three teachers; 1st teacher prefers to choose integration STEM starts with engineering disciplines combining with problem-based learning for her students to solve the problem in mathematics subject she taught. 2nd teacher prefers to choose integration STEM starts with engineering disciplines in her science classroom. 3rd teacher prefers to choose project-based learning which was an adult-sized cardboard chair for two months period completion. She wanted to relate this structure with the human skeleton.
Jehlička and Rejsek (2018)	A multidisciplinary approach to teaching mathematics and information and communication technology (2017)	The use of a specific example of mathematic calculation using ICT was conducted to increase the students' interest in STEM education. This approach helps the students to store numbers in computers memories, number notation in many numerical systems. The application of ICT in mathematics was to integrate the technology into the mathematics area.

Han, Yalvac, Capraro and Capraro (2015)	In services teachers' implementation and understanding of STEM project-based learning	All five teachers stated that they include a lesson plan included two or more areas. All of the teachers being interview stated that they recognize their role from a guide to a facilitator in STEM PBL activities. Five teachers had been interviewed and observed implemented PBL in science and mathematics class. They gave different understandings and enactment of STEM PBLs during the learning session. Case 1: John was a mathematics teacher designed a lesson plan of PBL and only conducted this approach only to a higher achiever student. He found that this group of students can design and solve the mathematics solution using a problem given related to all four disciplines. Case 2: Chira was a mathematics teacher believed the STEM approach had a positive impact on conceptual understanding mathematics contents. By implementing this approach with a lesson plan, she conducted a formative assessment by recording and giving a grade to their students' work. The evaluation and product outcome was divided into individual and group grade. Case 3: Susan was a mathematics teacher and eager to conduct STEM PBL in her classroom and her approach was called "thinking outside of the quadrilaterals" and combining this activity with the use of video clip. She believed that this approach helps her to attract their students' interest and improve their understanding of the mathematic concept. Case 4: Linda was a science teacher and design her lesson plan by combining environmental sciences, mathematics, English and social studies. She said that STEM PBL shows that the teachers became expert in doing a lesson plan and had a big picture for teachers to conduct and relate many subjects in the teaching session. She evaluates her students' readiness on daily reports individually and poster groups. Case 5: Robert believed that STEM PBL associated with students' future income. Robert preferred their students work.
Han, Capraro and Capraro (2016)	How Science, Technology, Engineering and Mathematics (STEM) Project-Based Learning (PBL) affects high,	After attending a few months of STEM education training, this teacher implemented STEM PjBL in her classroom and found that low achiever students show a higher increase in mathematic achievement and this PBL helps to reduce the gap

	middle and low achievers differently: the impact of student factors on achievement	of intermediate and higher achiever students in mathematics subject.
Ntemngwa & Oliver (2018)	The Implementation of Integrated Science Technology, Engineering and Mathematics (STEM) Instruction using Robotics in the Middle School Science Classroom.	One of the teachers conduct the robotics project in a classroom using her prior knowledge in robotic and integrate this idea and knowledge in her lesson plan. This groups of the teachers found that the collaboration with one of the technology teachers who was an expert in this robotic knowledge assist them to implement the STEM approach successfully. Many students show interest in asserting questions about robotics.
Ceylan & Ozdilek (2015)	Improving a Sample Lesson Plan for Secondary Sciences Courses within the STEM Education	The inquiry-based approach helps the students to integrate the acid-base content in engineering, technology and mathematics. These can be seen when the students were required by the teacher to conduct an acid bases experiment, watching animation related to the topics given at the computer laboratory and asked to create a slow-motion, doing a calculation and making a pH graph and building a pH metre in engineering disciplines. Then, the students will show their skills to create a simple project on how to protect the living organism from acid rain effects.