



Investigating the Implementation of Science Technology Engineer Math (STEM) in English language teaching

Linda Yuana[✉], Sri Wuli Fitriyati, Suwandi Suwandi

¹. SMA N 1 Boja, Kendal, Indonesia

². Universitas Negeri Semarang, Indonesia

Article Info

Article History:

Accepted 09 May 2022
Approved 04 July 2022
Published 23 December 2022

Keywords:

STEM, ELT,
Perception,
Implementation,
Evaluation

Abstract

STEM (Science, Technology, Engineering, Math) is an approach that integrated Science, Technology, Engineer and Mathematics in students' learning experience. This integration means to let students learn from the real problems that emerged in their real life and become problem solver. This study focused on STEM as an approach with one disciplinary and interdisciplinary subject. The objectives of this study are to analyze teachers' perception towards the implementation of STEM in English language teaching, to explain teacher's lesson plan in implementing STEM and to explain the implementation of STEM approach in English Classroom practices. By applying qualitative research approach, the researchers used questionnaire, interview and observation as the instruments for collecting the data. The results show that teachers have good perception on STEM. They believed that STEM could promote students' critical thinking and problem-solving skills. In terms of integrating STEM into lesson plans, teachers used problem-based learning and project-based learning as the teaching methods. During the classroom practices, teachers combined more than two elements of STEM. They let students to discuss about science-based material by using social media and some applications. It encouraged students to create a construction of the problem solving idea (Engineer). This study states the implementation of STEM in English language teaching particularly both in planning and also classroom practices, which never been studied before. It, hopefully, will give a clear picture of how to implement STEM in English language teaching effectively.

✉Correspondence Address :

Dawung, Rt 1, Rw 2 Blimbing, Boja, Kendal, Central Java
E-mail: lindayuana27@gmail.com

p-ISSN 2087-0108

e-ISSN 2502-4566

INTRODUCTION

Teachers in the twenty-first century are expected to deal with a time when students are more dependent on practical application of their knowledge than on conceptual understanding alone. Students must possess 21st-century talents in order to live in the coming years. The 4Cs—creativity, critical thinking, cooperation, and communication—indicate it. Many countries have implemented STEM because it is regarded as one of many strategies that may be utilized to foster students' critical thinking abilities. In response to pedagogical challenges in 21st century education, STEM based learning has become a prevalent practice in schools, colleges, and universities. It is in line with the government's desire to establish an educational system that focuses more on the application of information than simply providing students with conceptual understanding.

There are some researches done in a field of STEM as an approach and mostly done in high schools. A conceptual framework for STEM education and the blended or integrated learning on STEM studied and showed some effects for teachers and also their teaching processes. The key to preparing STEM educators is to first begin by grounding their conceptual understanding of integrated STEM education by teaching key learning theories, pedagogical approaches, and building awareness of research results of current secondary STEM educational initiatives (Kelley & Knowles, 2016). Along with the implementation of STEM especially in Senior High School context, there were benefits and barriers for STEM integration in the classroom (Moore et al, 2014) although STEM is stated as one of the innovations to balance educational challenges (McNally, 2012)STEM is applied as a set of approach or education system which blended the four elements in one circle of teaching learning process. There are still some barriers appear in a process of how teacher introduce the integrated STEM as an approach to students which link them back not only on the core concept, they have learned but also on the real life they have been through. Some of the challenges relate to teachers' ability to select

materials that are appropriate for both students' real-world situations and learning objectives. Additionally, teachers must implement classroom activities that connect information to students' real-world experiences rather than the other way around.

There are various misconceptions about how STEM is integrated in a teaching process because it is a new concept for the educational system. As stated by Pitt, some people define any activity that involves any of science, technology, engineering or mathematics as a STEM activity; others argue that intrinsic to the concept is some linking of two or more of the component areas of learning, and that real STEM must be more than the sum of its parts. There are some studies on teachers' beliefs and perceptions related to STEM talent development

Some studies underlined on teachers' perceptions and instructional method use, which perceptions aligned well with the framework of integrated STEM education. They gained a better understanding of teachers' beliefs about, perceptions of, and classroom practices using STEM integration. Teacher perceptions are a factor likely to influence their confidence and effectiveness teaching those concepts in both lesson planning or conducting learning activities in the class.

In conducting a lesson, teachers need to make a plan as their framework of how to deal with the teaching learning process. In case of making a plan for the lesson, there are some consideration should be taken by teachers. In the context of Indonesian curriculum which is a school-based curriculum. Teachers have the responsibility to develop their own syllabus and lesson plan based on students need and the characteristics of the school. As Bharati (2010) stated in her research that the development of those documents was not in line with the school-based curriculum, ignoring the level of difficulty as stated in the Bloom Taxonomy revised by Anderson. Regardless of level of experience or grade level taught teachers have significantly positive perceptions of PLPs as well as the associated PD activities (Ripley et all, 2017). Teachers can improve the quality of their

instruction as they gain more experience in teaching, if and only if, they are willing to self-reflect on their teaching practices and use their metacognitive skills as they iterate their instructional design.

Some studies highlighted in the use of STEM in language field as done by Schoettler (2015) in her study that tackles the severed relocated and complex issues of foreign language education, and of STEM education. The study done by (Roehrig et al. , 2012) give a background of how STEM literacy and English language learner (ELL). The highlight is that literacy can be used productively together as well as strategies for STEM teachers to help all students learn. Since STEM can be used and an approach of learning process, it need method to make it happen. Edmund et al. (2017) have studied the use of project-based learning (PjBL) in STEM class. PjBL and Problem based Learning (PBL) are stated to be the most applicable method to interpret STEM especially in a language teaching process, as PjBl and PBL link some literacy concept to real product or problem solution.

As a set of learning process, there are planning, classroom practices and also assessing students' achievement. Assessment in learning process can be in the form of "assessment of learning", "assessment for learning" and "assessment as learning". Assessment of learning is an assessment given by teacher in the end of the learning process, in purpose of find out the result of student's achievement after the learning process. It is also what so called as a summative assessment. The purpose of this kind of assessment is usually summative and is mostly done at the end of a task, unit of work etc. Assessment for Learning is all about informing learners of their progress to empower them to take the necessary action to improve their performance. Teachers need to create learning opportunities where learners can progress at their own pace and undertake consolidation activities where necessary. Assessment as learning, on the other hand, is the independence assessment done by students to know what the strength and weaknesses during his learning process. Assessment of STEM implementation in this

paper refers to deliberate effort to observe student learning through different means to evaluate where students are with respect to one or more specific learning objectives. We follow the reasoning elaborated in the "assessment triangle" (NRC, 2001; Pellegrino, 2014) that includes three important ends: cognition, observation, and interpretation

Studies on how to include STEM in the teaching of English as a second language are still few and far between. It is crucial to have a thorough grasp of how instructors view STEM and how they plan and implement it. Some research mainly focused on the opportunities and problems of STEM in English lessons. so that it can be a resource for English teachers in the future. The main objectives of this study are to analyze teachers' perception on the implementation of STEM as an approach in English language teaching especially when they have already had training about it. This is a study to develop an understanding of how teachers perceive the implementation of STEM in English language teaching. This study also concerned with how teachers construct a lesson plan on STEM and use it as their practices in the classroom. Hence, this research entitled "The implementation of Science, Technology, Engineer and Math (STEM) in English language teaching at SMA N 1 Boja"

METHOD

This current study used a descriptive qualitative case study. This study focused on investigating teachers' perception of STEM in English language teaching, and how they perceive STEM as an approach. Their belief is that STEM promotes students' critical thinking and problem-solving skills. In addition to teachers' perceptions, this research also investigated the implementation of STEM during the teaching and learning process.

The research participants were 3 English teachers in SMA N 1 Boja. They teach different grades and have been teaching for more than ten years. Since SMA N 1 Boja has conducted training to implement STEM as an approach, so

all of the subject teachers also have attended that kind of training.

The role of researchers in this study was as data collectors, data analysts and data reporters. The instruments used were a questionnaire to find out the teachers' perception, a set of interviews to find the teachers' planning and observation (both document and classroom activity). The data gathered was in form of descriptive qualitative data collected by the following procedures : (1) giving the questionnaire, (2) formulating interview, (3) doing observation (both document and classroom activities), (5) collecting data from questionnaire, interview and observation

After the data were collected, they were categorized based on the research questions which are the teachers' perception toward STEM, the implementation of STEM in lesson plan and classroom activities and also the evaluation of STEM as the whole program.

This study included triangulation to ensure that the research was credible and that the findings and interpretations were accurate. This is a process of corroborating evidence from different individuals, types of data, or methods of data collection (Creswell, 2012). From one of those options, this study sought evidence from a different individual, especially those who experts in English language teaching. The findings were submitted to an expert and examined to see whether or not the researcher misinterpreted the analysis.

RESULTS AND DISCUSSIONS

The present study aimed at examining teachers' beliefs in STEM, the integrating of STEM in lesson plans, and the implementation of STEM into English language teaching.

Teachers' perception on STEM implementation

The findings of the English teacher perception in implementing STEM were gathered through questionnaire and set of interviews. They were carried out before the document and classroom observation. Teachers

showed their understanding of STEM yet they thought it would not be possible to insert STEM elements in all topics.

The questionnaire consisted set of statements revealing about the preparation in implementing STEM, method related, effects for students including critical-thinking and problem-solving skills and also how teachers dealt with it. Every statement should be responded by putting a tick on one of box among strongly agree (SA), agree(A), uncertain(U), disagree(D), strongly disagree (SD), reflecting the perceptions of teacher toward the statement. There were 20 statements should be responded by teachers. All responds were scored to know how positive the perception was. The answer would be given 5 for strongly agree, 4 for agree, 3 for uncertain, 2 for disagree and 1 for strongly disagree. So, the highest score of the questionnaire was 100. Bigger score showed better perception teacher had.

Since STEM was believed as one of the approaches that promoted students critical thinking and also problem solving, researcher provided the questionnaire focused on this part. It was included how STEM could improve students critical thinking in the way it dealt with promoting students' inquiry skills, scientific literacy, and also collected information related to the design from different disciplines. In term of solving problem, the questionnaire focused on whether STEM had positive impact on students' decision-making skills, using English to solve the problems they had in their surrounding and also students' experience in real world. Since implementation not only about the teaching process but also the preparation and evaluation, the questionnaire also focused on how teachers prepared their classes implementing STEM and whether STEM could be applicable in English language teaching.

On the other hand, the interview was given in the form of open-ended questions. It was about the definition, the characteristics, the impact for students, how to prepare it and also the strength and challenges. The responses of the teachers in the interview session were considered to be more representatives of the teachers' true perceptions

because in this session they did not have any guidance. In the interview session, the answer could be varied since they had responded based on their own understanding and it could be extended based on teacher's answers.

In term of preparation, three teachers answered agree for statement that the preparation in implementing STEM took more time than other approach or method. Otherwise, T3 answered disagree for this statement. This statement followed by the next one about whether teacher should create their lesson plan and also how lesson material in STEM dealt with contextual learning or related to real life. In creating lesson plan, all teachers agree that teachers should create their own lesson plan. In focusing about the relation between STEM and contextual learning, all teachers strongly agree and agree that lesson material in implementing STEM should be provided by real context in students daily life especially in encouraging students to use English in daily life context.

Another part of questionnaire which talking about how STEM promoted students critical thinking, all teachers answered between strongly agree and agree. All three teachers strongly agreed that STEM had a positive impact on critical thinking skills and also on decision-making skills. T1 and T2 answered strongly agree and T3 answered agree for statement that STEM led students to collect information related to the design from different disciplines. All three teachers answered strongly agree for STEM promoted student's inquiry skills by raising questions for students to investigate and Inquiry process in STEM provides more questions and requires higher thinking skills in ELT. From those statements, it could be concluded that for the statement dealing with STEM promoting critical thinking teachers had good perceptions since all teachers answered strongly agree and agree.

In term of how STEM could promote students' problem-solving skills, all teachers answered strongly agree for statements that STEM improved problem-solving skills, STEM made students use their English to solve their

real-life problems and STEM process was challenging for students.

Since STEM is an approach, researcher also proposed a statement about what method could be the element of it. Two statements were asked to be responded about teaching method along with the purpose of STEM which could promote critical thinking and problem-solving skills. The statement was about Problem based learning and Project based learning. All teachers agree that problem-based learning and project-based learning were two important elements for STEM approach. It was also seen from the lesson plan made by teachers that they tend to use the two methods in implementing STEM.

According to the data interpretation, three teachers of SMA N 1 Boja had good perception in implementing STEM. It could be seen in every item of questionnaire they had filled. They believed that STEM could improve student's ability of critical thinking and problem-solving skills. Their believed that Problem-based Learning and Project-based learning were two appropriate method used in implementing STEM. It was aligned with their practices in classroom which they use those two methods in implementing STEM. As stated by Berland et al. (2014) Some studies underlined on teachers' perceptions and instructional method use, which perceptions aligned well with the framework of integrated STEM education

Moreover, teacher had good perceptions on how STEM could give positive impacts to students. Teachers agree that STEM could promote students critical thinking, problem-solving skills, collaboration skills and promotes inquiry skills. That's why in designing STEM implementation, teachers were confident enough to create learning activities which supported the learning objectives and promotes students' skills. Teacher perceptions are a factor likely to influence their confidence and effectiveness teaching those concepts (Darling-Hammond & Bransford, 2005)

The Lesson Planning and Classroom Practices

The data of how teachers constructed lesson plan was gathered from interview,

document observation and also classroom observation. In constructing the syllabus, teachers used the given syllabus by the government but since it was too broad, teachers made it detailed through teachers' forum. It will give insight to English teachers on how to construct a meaningful lesson planning using STEM.

The construction of Lesson Plan including how teachers designed the classroom activities, planned the use of STEM component in English language teaching, the assessment and also reflection. Interviews were given to all teachers in different time to focusing on how their preparation in constructing Lesson Plan, especially in implementing STEM in their classroom.

The interview was coped on the time of construction, consideration used and also how to insert the component of STEM in lesson activity. The result showed that all of teachers made the lesson plan in the beginning of the academic year. It was said that it was the mandatory from the principal. They made it for the whole basic competence in a year. T1 said that it was actually difficult for them to imagine the whole year activity, so most of the time she just used the previous year lesson plan and made some revisions. T2 also gave similar answer, which was about the time of construction. It was not in the beginning of the lesson but the beginning of academic year as it was mandatory. But sometimes she made the simple lesson plan before teaching to be fitted into latest information. T3 said that he prepared the lesson plan every time he wanted to teach. This lesson plan can be driven from the documents he had submitted to school or made it right away before class.

In making the lesson plan, T1 said that she made the lesson plan herself but first she had discussion with some colleague who teach same subject especially in a same level. T2 preferred to have discussion with English teacher in school and made lesson plan as the result of discussion, so she could get many ideas from her class. T3 chose to make lesson plan himself all the time because he could modify it based on his passion

and what students in his class needed. After constructing lesson plan, two teachers, T1 and T2 consulted the lesson plan into curriculum board at school to have more insight and to be approved by headmaster. Meanwhile T3 did not consult the lesson plan because he thought that lesson plan was used for himself so he did not need to consult it. He just submitted it to be approved by headmaster.

In constructing lesson plan teachers needed some references. All teachers said that they used syllabus as the first consideration. It was said because in syllabus there were many items that already stated for learning process. The only thing teacher should do was to develop the learning process and assignment in more details. T2 added the information that she also use handout book to be considered and reference on how to construct lesson plan, especially in how to plan learning activities.

After considering some reference in constructing lesson plan, the next step is inserting STEM in their lesson plan. Based on interview, teachers first analyze the basic competence and core material that could be taught using STEM. After that teachers constructing the syllabus. These two things were the consideration to create lesson plan in implementing STEM in English language teaching. Teacher first decided material, chose which appropriate in implementing STEM and then create learning activities using problem-based learning or project-based learning. After stated material and learning activities teachers decided the assessment which matched into the learning process. T3 said he put science and technology learning objectives and also main activity in learning process.

Besides interview, researcher also did document observation. As stated before, teachers in SMA N 1 Boja were obligated to construct lesson plan for the whole year program in the beginning of academic year. So, one documents of lesson plan/*RPP* consisted of more than one meeting and also represented more than one basic competence. Researcher only observed lesson plan which implementing STEM in English language teaching. There were three

lesson plans represented three teachers. for Teacher 1 (T1), the lesson plan chosen was in grade XI with the topic “healthy environment”, this lesson plan was for two meetings. Lesson plan from Teacher 2 (T2) was for grade XII, the topic was “health problems in teenager’s life”. While for Teacher 3 (T3) the lesson plan was for grade XI, the topic was “natural phenomenon and natural disaster”. The lesson plans then observed using rubric guidance. This instrument was derived from the Ministry of Education’s guidance of learning activities and assessment process and it was standardized by the government. The rubric consists of 7 parts, with each part consisted many statements as the considerations.

According to the result of lesson plan rubric, almost all items in rubric was fulfilled by teachers, only some of the items became challenging for them for some reasons. All teachers were finding it was difficult in providing material which fulfilled the need of each students since there were many students in the class and each teacher taught more than five classes. T3 found difficulties in term of deciding indicator and learning activity. In term of deciding indicator, some of his indicators did not match with the competence given by government.

In this research, three English teachers in SMA N 1 Boja constructed the lesson plan briefly and showed the step by step guidance clearly. They first analyzed the basic competence, constructed syllabus then made it details by constructing lesson plan. It can be seen from the rubric data gathered in this research. All items were fulfilled. It is a line with what Cox (2019) said that a lesson plan is a detailed step-by-step guide that outlines the teacher’s objectives for what the students will accomplish during the course of the lesson and how they will learn it.

In implementing STEM, teachers showed a flows of Engineer Design Project (EDP) from the opening, main activities to the closing. Two teachers were using Project-Based Learning and one teacher was using Problem-based Learning. They agreed that in implementing STEM, those two methods are the most applicable method as stated by Edmund et al. (2017) overview about

the use of PjBl in STEM class. Project based Learning (PjBl) and Problem based Learning (PBL) are stated to be the most applicable method to interpret STEM especially in a language teaching process.

The EDP of STEM in T3’s lesson plan also lacks of implementation of PjBl. In the document, there was only Problem based Learning related to the science aspect of STEM. Beside those challenge, all lesson plans were fulfilled the items needed as a good lesson plan.

In short, the syllabus and lesson plans were well arranged and they also showed how the planning was constructed in implementing STEM in ELT. Teachers considered the rules of curriculum in the form of their lesson plans. They provided all elements required by curriculum, although there was still some challenge they faced, for example in deciding the material which suited to students’ characteristics. It was difficult for them because they had to analyze the need of all students, even though they had a lot of students in the class.

STEM programs educate the whole student, emphasizing innovation, problem solving, critical thinking, and creativity (Tennessee STEM Innovation Network, 2012, as cited in Turner, 2013). Assessment done in this research measured student’s achievement in creating the product by a rubric in the end of the project. It was done in form of a summative assessment.

The whole process of critical thinking and problem-solving skills were measured through question and answer during the lessons. Both of them are done in form of formative assessment. However, in this research there was no data about how students are assessed dealing with how they emphasize innovation. It happened because the concept of STEM was interdisciplinary, so this kind of assessment was done by another subject.

Assessment in this research refers to a deliberate effort to observe student learning through different means to evaluate where students are with respect to one or more specific learning objectives. We follow the reasoning elaborated in the “assessment triangle” that

includes three important ends: cognition, observation, and interpretation.

According to Roche, there are characteristics of best STEM implementation. First, hands on STEM lessons. The best STEM lesson requires students to interact with the concept with their hand. Whether it was through designing, building, creating, role-playing, or any other inventive and discovery-based process. To be most effective, hands-on activities should mimic a real-world scenario as much as possible. In this research, teachers mentioned they use school's surrounding as one of source, they let students to study from their real-life source. T3 in his class, he used science element by talking about flood and another natural disaster as the main material in learning activities.

Still based on Roche, great STEM material addresses everyday problems. In this research, teachers consider every day's problem as topic students should cope with. T2 in her class, discussed about teenager's health problem considering that she taught grade 12 of senior high school. It is relevant because in this class, students discuss their own problem and share to others to find the best solution. T3 chose explanation as his concern to implement STEM in the class. He chose natural phenomena and natural disasters as topics to be taught. Since there was a landslide and volcano eruption near the school, so teacher used it as a topic to be discussed

From the data interpretation and comparison above, we can mention that the construction of Lesson plan and STEM implementation in classroom activities, including material and assessments fits to STEM ideas.

The Evaluation of the whole STEM program

The evaluation meant in this study is the program evaluation, in which the researchers want to provide information on how school conducts an evaluation of a program inside the classroom and within the scope of the school. It will provide an example of how the school should conduct an evaluation of every program offered at the school.

Data for evaluation of STEM implementation was gathered from both interview and observation. From the interview, the data gathered was as follows. First was about the challenge face by teacher. T1 said that it was hard to implement STEM for all English material, the teacher should analyze it first. T2 said that implementing STEM needed more time to prepare than another approach especially when preparing the assessment. We should construct an instrument that appropriate for the need of STEM activities in class. While T3 said that sometimes it was hard to balance the language focus and also STEM content. Teachers tend to focus more on the project done by students but not the core material.

In answering the questions about how effective the implementation of STEM, teachers did reflection in each meeting. It was held in the end of the meeting. They used many kinds of tools to ask students how about the lesson today. They focused on four elements of STEM to be asked to students. This note was data for teachers to be analyzed and to find out whether it the implementation of STEM run well or not.

Based on the interview, teachers said that the key to success in implementing STEM in ELT was communication with students about the project they would involve, this communication could be in the form of diagnostic assessment. Another key was that teachers should be able to analyze the basic competence and linked it with the elements of STEM.

There were some strengths they said about implementing STEM. First of all was STEM made students more creative, because by implementing STEM students were involved in making a problem-solving idea became reality through project-based learning activities. Besides, by concerning on science related to student's life, they would develop their critical thinking skill. They were also engaged with technology which became their nature in life.

The observation was done about how teachers evaluated the STEM implementation in classroom. It was done in form of reflection conducted by teachers in their own classes. From this activity teacher would find out the

effectiveness of implementing STEM, what was the strength and also weaknesses. Based on evaluation also, there was a program of school which called teacher model. In this program, one teacher become a model to conduct learning activities and another became observer. After the learning process, they would sit together to discuss how STEM implemented in the class.

To know whether or not STEM program run well, evaluation of the whole program was needed. In this research, evaluation was done in two kind of form. First, in a scope of classroom where teachers did reflection with students on how the learning activity done. Second, in a scope of school where there was a program involving all teachers to sit together and had reflection on how the program was going on.

According to Hovardas, there are some items to be evaluated in STEM implementation. There are integrated STEM framework, design of STEM learning scenario, implementation of STEM scenarios, impacts of STEM project. Some of those items were evaluated in school forum. The design and implementation were discussed using rubric that had been filled when teachers observed model teacher during learning process. The impacts of STEM project was evaluated during classroom reflection.

CONCLUSION

Based on the data analysis and discussion, it can be concluded that all teachers have good perception of implementing STEM in the English language teaching. They assumed that STEM can improve students critical thinking and problem-solving skills. They also perceive Problem-based Learning (PBL) and Project Based Learning (PjBL) can be conducted as the supported method of STEM approach. The implementation of STEM consists of three steps which are planning, classroom practices and giving assessment. To make it complete, STEM implementation should be evaluated in scope of classroom and also schools. In planning STEM implementation, teacher should analyze first the basic competence and core material to decide learning objectives which in line with STEM.

Teachers need to construct syllabus and lesson plan. Syllabus is the guidance of the whole learning activity while Lesson Plan is the guidance to run classroom activities in details. In implementing STEM, teachers also need to prepare material which related to science and technology also Math, like statistic data, tab and graphic if it is possible. Besides, teachers also need to prepare assessment which fulfill the need of STEM implementation since STEM usually done in form of interdisciplinary subject matter. Three teachers in SMA N 1 Boja did well in planning, implementing STEM in classroom practices and also assessing students learning activity

REFERENCES

- Banks, F., & Barlex, D. (2014). *Teaching STEM in the secondary school: Helping teachers meet the challenge*. Routledge.
- Berkant, H., G, & Baysal, S. (2017). *Allosteric learning model in English lesson: Teachers' views, the instructions of curriculum and course book, a sample of daily lesson plan*. *Universal Journal of Educational Research* 5(1), 84-93.
- Berland, L., Steingut, R., & Ko, P. (2014). *High school student perceptions of the utility of the Engineering design process: Creating opportunities to engage in engineering practices and apply Math and Science content*. *Journal of Science Education and Technology*.
- Bharati, D.A.L. (2010). *Teachers' professional development through an observation in immersion classes based on the documents and teaching and learning process*. *Language Circle Journal of Language and Literature*, IV/2
- Borg, S. (2009). *Introducing language teacher cognition*.
- Borg, S. (2003). *Teacher cognition in language teaching: a review of research on what language teachers think, know, believe, and do*. *Language Teaching*, 36 (2), 81-109.

- Carpraro, R, Carpraro, M & Morgan, J. (2013). STEM Project based-Learning. Sense publisher
- Cockrum, T. (2014). Flipping your English class to reach all learners : Strategies and lesson plans. Routledge.
- Collier, S., Burston, B. and Rhodes, A. (2016). Teaching STEM as a second language: Utilizing SLA to develop equitable learning for all students. *Journal for Multicultural Education*, 10 (3), 257-273.
- Cox, J. (2019). Here's what you need to know about lesson plans.
- Darling-Hammond, L., & Bransford, J. (2005). Preparing teachers for a changing world. San Francisco, CA: Jossey-Bass.
- DelliCarpini, M & Alonso, O.B. (2014). Teacher education that works: Preparing secondary-level Math and science teachers for success with English language learners Through content-based instruction, *Teacher Education that Works*
- Ejiwale, J. (2013). Barriers to successful implementation of STEM education. *Journal of Education and Learning*, 7 (2), 63-74.
- English, L. D., & King, D. T. (2015). STEM learning through engineering design: fourth-grade students' investigations in aerospace. *International Journal of STEM Education*.
- Goldenberg, C. (2008). Teaching English Language Learners: What the research does - and does not – say. *ESED 5234 Master List*. 27.
- Gomez A., & Albrecht, B (nd). True STEM Education. *Technology and Engineering Teacher*, 73 (4), 8.
- Hafiz, N. R. M., & Ayop, S. K. (2019). Engineering Design Process in Stem Education: A Systematic Review. *International Journal of Academic Research in Business and Social Sciences*, 9(5), 676–697.
- Han, S, Yalvac B & Carpraro M. (2015). In-service teachers' implementation and understanding of STEM project based learning. *Eurasia Journal of Mathematics, Science & Technology Education*, 11(1), 63-76.
- Herro, D., & Quigley, C. (2016). Innovating with STEAM in middle school classrooms: Remixing education. *On the Horizon*, 24(3), 190-204.
- Hidayat, R. N, Rukmini, D. Bharati, D.A.L. (2019). Developing problem-solving based assessment to stimulate critical thinking and creativity of students writing skill. *English Education Journal*, 9 (2), 164-171
- Hoffman, Lisa and Zollman, Alan. (2016). What STEM teachers need to know and do for English language learners (ELLs): Using literacy to learn. *Journal of STEM Teacher Education*, 51 (9).
- Hom, J. (2014). What is STEM education?
- Honey, M., Pearson, G. & Schweingruber, H. *STEM Integration in K-12 education: status, prospects and an agenda for research*. National Academies Press. Vol. 500
- Icel, M. (2018). Implementation of STEM Policy: A Case Study of a STEM-Focused Urban Charter School. *Journal of STEM Eductaion*, 19 (3).
- Ilmi, I. K & Fitrianti, S. W. (2019). Teachers's perception, plans. And their practices on teaching vocabulary in context at SMP N 1 Parakan, Temanggung. *English Education Journal*
- Jolly, A. (2016). *STEM by design : Strategies and activities for 4-8 grades*. Taylor & Francis Ltd
- Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, 3(1).11
- Khani, R., & Hajizadeh, A. (2016). The construct definition of an English language teachers' content knowledge. *The Qualitative Report*, 21(5), 972-992.
- Koo, A. C. (2008). Factors affecting teachers' perceived readiness for online collaborative learning: A case study in Malaysia. *Educational Technology & Society*, 11 (1), 266-278.

- Kumaravadivelu, B. (2006). *Understanding language teaching: from method to post method. esl applied linguistics professional series.* Mahweh, NJ: Lawrence Erlbaum.
- Lantz, H. (2009). *Science, technology, engineering, and mathematics (STEM) education. What form? What function.*
- Margot, K & Kettler, T. (2019). *Teachers' perception of STEM integration and education: a systematic literature review.* *Journal of STEM Education.*
- Maslyk, Jaice. (n.d). *To assess or not to assess STEM challenges (Free Rubrics Included).*
- McNally, T. (2012). *Innovative teaching and technology in the service of science: Recruiting the next generation of STEM students.* *Journal of the Scholarship of Teaching and Learning, 12(1), 49-58.*
- Moore, T. J., Stohlmann, M. S., Wang, H. H., Tank, K. M., Glancy, A. W., & Roehrig, G. H. (2014). *Implementation and integration of engineering in K-12 STEM education. in engineering in pre-college settings: synthesizing research, policy, and practices.* Purdue University Press
- National Academies of Sciences, Engineering, and Medicine. (2018). *English learners in STEM subjects: Transforming classrooms, schools, and lives.* The National Academies Press.
- Pitt, J. (n.d). *Blurring the boundaries-STEM education and education for sustainable development.* *Design and Technology Education: An International Journal, 14*
- Rachim, F. 2019. *How to STEAM Your Classroom.* Agtifindo
- Rinke. R C, Brown, G W, Kinlaw, R.C, Cappiello, J. (2016). *Characterizing STEM Teacher Education: Affordances and Constraints of Explicit STEM Preparation for Elementary Teachers*
- Ripley, J. W.,. (2016). *Teacher perceptions of individual professional learning plans.* *Electronic Theses and Dissertations.* Paper 2949.
- Roehrig, Gillian H.; Moore, Tamara J.; Wang, Hui-Hui; and Park, Mi Sun. (2012). *Is Adding the E Enough?: Investigating the Impact of K-12 Engineering Standards on the Implementation of STEM Integration.* School of Engineering Education Faculty Publications. Paper 6.
- Rohde, Aaron. (2019). *Assessment and engagement strategies for STEM".* Department of Teaching, Learning and Teacher Education. 107.
- Schoettler, S. D. (2015). *STEM education in the foreign language classroom with special attention to the 12 german classroom.* *Dissertations and Theses.* Paper 2313.
- Scott, C. (2012). *An investigation of science, technology, engineering and mathematics (STEM) focused high schools in the U.S.* *Journal of STEM education, 13 (5)*
- Seage, S.J., & Türegün, M. (2020). *The effects of blended learning on STEM achievement of elementary school students.* *International Journal of Research in Education and Science (IJRES), 6(1), 133-140.*
- Smith, K.,L. Rayfield, J., & Mc Kim, B. R. (2015) *Effective practices in STEM integration: Describing teacher perceptions and instructional method use.* *Journal of Agricultural Education.*
- Stohlmann, M. Tamara J. Moore, & Gillian H. Roehrig. (2012). *Considerations for teaching integrated STEM education.* *Journal of Pre-College Engineering Education Research, 2(1), 28-34*
- Stubbs, E. A.,& Myers, B. E. (2016). *Part of what we do: Teacher perceptions of STEM integration.* *Journal of Agricultural Education, 57(3), 87-100.*
- Susanto, D., A., Miyono, N. Affini, L. N (2019). *STEM in English language teaching at high schools in Central Java Indonesia: Opportunities and challenges.* *Journal of Physics. International Conference on Education and Technology (ICETECH).*
- Syukri, M., Halim, L., Meerah, T. S. M. (2013). *Pendidikan STEM dalam Entrepreneurial Science Thinking "Escit": Satu*

- Perkongsian Pengalaman dari UKM untuk Aceh. In Aceh Development International Conference.
- Todd R. Kelley¹ & J. Geoff Knowles. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*
- Tsupros, N., Kohler, R., & J.Hallinen. (2009). STEM education: A project to identify the missing components. Intermediate Unit 1 and Carnegie Mellon.
- Turner, K. (2013). Northeast Tennessee Educators' Perception of STEM Education Implementation. *Electronic Theses and Dissertations*. Paper 1202.
- Ur, P. (2009). *A course in language teaching*. Cambridge: Cambridge University press
- Wahyuni, S. (2018). Evaluation of pre-service English teachers 'integration of educational technology into their lesson plans. *Language Circle: Journal of Language and Literature*, 12(2), 227—234.
- Wang, H., Moore, T. J., Roehrig, G. H., & Park, M. S. (2011). STEM Integration: Teacher perceptions and practice. *Journal of Pre-College Engineering Education Research (J-PEER)*, 1(2), Article 2.
- Yakman, G., & Lee, H. (2012). Exploring the exemplary STEAM education in the US as a practical educational framework for Korea. *Journal of Korea Association Science Education*, 32(6), 1072-1086.
- Zollman, A. (2012). *Learning for STEM Literacy: STEM Literacy for Learning*.