Integration of STEM education in history learning

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Article Info

ABSTRACT

The 21st century needs pupils with learning ability and necessary skills, particularly critical thinking skills instead of content focused. The study of science, technology, engineering and mathematics (STEM) education approach can lead teachers to a new teaching approach in history learning. Through this approach, the teachers can create a new way of teaching history integrated with STEM. This study used a qualitative approach. Data collection in this research using pupil's work samples, interview, and the teacher journal. This research was conducted in two high school and two vocational school in the urban area. The findings showed that the teachers integrated one of the historical thinking skills and understanding history. The skills are still in the lower level of historical thinking skills. For historical teaching skills to be effectively integrated in history learning, teachers need to be trained so the pupil's historical thinking skills can be enhanced through the integrated history learning with the STEM approach.

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1. INTRODUCTION

The industrial revolution 4.0 and 21st century learning require pupils to have the abilities and skills needed to deal with them, particularly in critical thinking skills [1]–[3]. To face these challenges, lots of innovation undertaken by many countries to realize the education-oriented on outcomes that have the 21st skills. One of the innovations carried out in education sector is to prepare qualified and competitive human resources, education is an important means of achieving it all because without education everyone will not be ready to compete in the current era. The 21st century is characterized by the development of information and communication technology (ICT) that change rapidly [4]. The development of technology and information inevitably touches all fields, including education. It causes the global competition become tighter, which demands that competence must adapt to the skills needed in 21st century [5].

The 21st century skills that pupils need to have is learning paradigm which emphasizes the ability of pupils to think critically, be able to connect knowledge with the real world, mastering in communication, information, technology, and collaboration [6]. The science, technology, engineering and mathematics (STEM) education approach is very appropriate to be applied in the education system because STEM aims to make pupils learning have the competence to think critically. Fostering critical thinking skill can be improved through history learning. Learning the actual history is not just simply answer the question about what to teach, but also the way of learning and historical knowledge for the benefit of learners. Therefore, history learning must be carried out to be able to find, instill values, and transform the messages behind the historical

reality. In the process of learning history, pupils do not just master the teaching material but also can take lessons from a learned historical event.

History learning should be directed to help pupils develop historical intellectual skills [7]. In this case, pupils need to be firmly accustomed to and invited to ask, think, and reflect on the topic being studied. In history learning, teachers must carry out effective learning. History teachers must emphasize the importance of learning as a personal process, where each pupil builds knowledge and personal experience. In this case, pupils must be introduced to how to find supporting evidence of the historical events being studied. Pupils must also be allowed to provide interpretations of evidence that are considered relevant to the historical events being studied. If history learning can be done in such a way, then intellectual history skills can be achieved optimally.

History learning that requires historical thinking skills that should be developed by history teachers has not been carried out effectively [8]. Furthermore, the facts in the field that history learning is required pupils to memorize as a form of outcome in history learning. In this case, history subjects becoming unattractive and makes pupils' learning motivation decline. In history learning, some skills should be developed by every history teacher, namely historical thinking skills. These skills are in line with the 21st century required. Historical thinking skills are skills that pupils must have when they learn history in the hope that it can make pupils think more critically in answering every historical reality that has occurred. In line with the times, the Indonesian government is trying to find and implement innovations in education through the 2013 Curriculum that includes STEM education to be integrated into learning. Through working together with United States Agency for International Development (USAID) in Indonesia, began to try to develop this STEM-based learning model [9].

Previous research [10] on integrating STEM approaches in social science studies found that social studies teachers have the intention to practice STEM in social studies although it still needs to be developed in practice. Nevertheless, several researchers had fostered a multidisciplinary program planned to support innovative intuition by consolidating concentrates art studies, humanities, and STEM. Through the scholastic rebuilding of conventional education models, this educational program will be at the front line of including students in multidisciplinary critical thinking that can create modern scientific and technological innovations needed to overcome complex problems facing human society [11]. The objective of this research was to examine the integration of STEM education into history instruction in secondary level. The research question used is: does STEM integration have an impact on pupils' historical thinking skills? There are two advantages obtained from this research. First, the teacher knows whether pupils enhanced their historical thinking skills after learning history using the STEM approach. Second, pupils have different learning experiences by carrying out through the STEM education.

The STEM education approach is a methodology in defeating issues in reality by directing the attitude of pupils to thinking like specialists and researchers [12]. Through this approach, pupils are directed to become issue solvers, creators, trailblazers, fabricate freedom, think legitimately, innovation proficient, and can connect the STEM approach with the work atmosphere [13]. STEM approach applies critical thinking based discovering that intentionally puts logical request and the utilization of math with regards to planning innovation as a type of critical thinking. Scientific inquiry is rare in technology education and technology design activities are rare in science classes. Nevertheless, in regular daily existence, scientific design and investigation are routinely applied at the same time as specialized answers for true issues.

In the STEM education approach, teacher must provide opportunities for pupils to develop creative ideas and expertise in stemming mindset according to the relevant context [14], [15]. By implementing STEM education in history learning by promoting the active activities of pupils in the learning process will provide positive opportunities for pupils to develop all their potential in learning. Historical thinking skill is essential because it can improve pupils' critical thinking skills [16]. Pupils learn from history to improve critical thinking skills [17]. Pupils ask critical questions and answer with arguments accompanied by factual evidence [18]. The ability to think critically is very important because it is one of the skills that pupils must have in the twenty-first century [19]. Thus, history learning can improve critical thinking skills because one of the competencies that pupils must have is the learning process that can accommodate pupils' critical thinking skills cannot be done with a one-way learning process. Learning one direction, or centered on the teacher, would handcuff criticality pupils in teaching material. Pupils receive material from one source with a tendency to accept and cannot criticize.

The "doing" in historical learning is the most crucial [20]. Pupils need to analyze information and establish arguments supported by evidence across all the domains of social studies. There is three-way to connect social studies with the STEM approach in classroom. The first is focus on social studies other than history. The pupils regularly believe that the ancestor was unintelligent because they didn't have the information we have now. Requesting the pupils envision how basic machines may have been utilized to assemble the Roman aqueduct make them fully aware of how extraordinary designing of the past truly was.

Secondly, execute profession centered exercises to add social context studies without context does not make much sense for pupils. The pupils need to comprehend the pertinence of what they learning realizing as far as the needs of the cutting-edge world [21].

Thirdly, use project-based to extend understanding, based on the work of actual STEM careers opens pupils' and educators' eyes to true-setting for social studies. In the reality, history teachers still use conventional methods of lecturing and memorizing. This situation of course makes history learning dull and unable to improve historical thinking skills [22]. To be able to optimize history teachers in improving historical thinking skills, the teacher can use the STEM education approach because the STEM education goals are similar in learning history, namely they both want to make pupils who have useful abilities in dealing with more complex and demanding situations. They use critical power in every decision making.

2. RESEARCH METHOD
2.1. Design
This study use a qualitative methodology [23], in particular, the type of research used is descriptive method that tried to explore the significance of STEM approach in the application of historical instruction which requires pupils to have and enhance historical thinking skills. History teachers teach with historical materials designed using STEM approaches in lesson plans that have implemented higher order thinking skills (HOTS), so that qualitative research runs well and gets quality data. Researchers interpret a phenomenon using a natural background and involve various methods. This study did not use statistical data, but through data collection and analysis. This research procedure will produce descriptive data, namely in the form of words from the observed data.

2.2. Participants
This study was conducted in four public high schools in Tangerang, Banten Province, Indonesia. The study involved 178 pupils from 10th grade classrooms. The researchers also involved four certified history teachers as a participant in this research.

2.3. Data gathering
Three data collection techniques were used in this research. There are pupil work samples, in-depth interview with pupils and teacher, and teacher journal. Besides, pupils requested to answer a pupil survey on their inclinations toward integrated history learning using STEM education approach.

2.3. Data analysis
Researchers use a variety of sources, methods, and theories to provide supporting evidence as validation of the results of this study. Various data sources are used in research, namely student work, teacher data, and interview results, so that only valid data is used to achieve research results. The analysis data using descriptive analysis with triangulation to make sure that all data valid and reliable.

3. RESULTS AND DISCUSSION
Based on the interview from the history teachers in high schools (SMA) and vocational schools (SMK). The teachers might face the obstacles as they try to implement the STEM education approach in history learning. The teachers argued that:

> "*My school system only focused on pupils testing, so the principal and vice principal of academic and curriculum want me to teach toward test objective*."

Another teacher said that:

> "*I have a little control to what I teach or when I teach. I must stay with the curriculum guide*."

The interview result with the history teacher showed that history learning in the classroom is still limited to the memorization level, this is due to the demands of the learning system in schools which always emphasizes objective tests. Schools yet haven't developed a test that looks at critical Thinking. It showed that history teacher would need to make their classroom more flexible and the opportunity to continue learning through ongoing professional development.

Based on observations from pupil work samples, it is still seen that the history teacher gave the assignment still shows that learning activities are at a low level of the expected historical thinking skills. The history assignment that given to pupils is limited to summarizing historical events from the teaching

materials provided by the teacher, for the example the pupils recap the material from the textbook and the teacher grade that assignment.

The next pupil assignment which shows that the history learning process in the classroom still cannot improve critical thinking skills is to provide questions of the lower order thinking skills (LOTS) type which does not make pupils optimize critical thinking skills and analytical skills in assessing why and how historical events took place. Whereas, if the history teacher can assign the assignments to pupils by emphasizing historical thinking skills, it is hoped that pupils' critical thinking skills and comprehensive historical understanding can be further improved.

Based on interviews with pupils, it shows that they feel bored to study history because the history teachers are still limited to conveying information that they can find themselves through books and the internet. They want to learn history by linking every event that has occurred with other subjects they learn at school. Moreover, for the vocational pupils who do have basic skills in the fields of engineering, business and accounting, they want to study history while being related to the vocations they take. The pupil said:

> "*I want to learn the history of the vereenigde oost-indische compagnie (VOC) era about how they manage finances, whether accounting has been applied during the VOC era in Indonesia.*"

So, they feel it is important to study history because by learning history, they can also understand why these events occurred not just when and what happened in the past.

History learning which still does not make pupils able to improve critical thinking skills and has not integrated history subjects with other subjects is also seen from the teacher's daily journal. Based on observations made through teacher journals, it appears that teachers do teach based on the demands of the school curriculum which must teach history conventionally. This condition happened because the demands of the formative test to be carried out are still limited to low-level objective tests. In teaching history, the teacher only teaches what is provided in the textbooks that have been provided by the government, even though the teacher can teach local history around the pupil environment, in particular history teachers in vocational schools should be able to bring history lessons with majors/competencies taken by the pupil. This happens because the national-based school examination (USBN) demands the material that is already available in textbooks that have been provided by the government.

History lessons that carried out by teachers in the classroom still show learning activities that made pupils unable to optimize HOTS. History teachers still take pupils to study historical events chronologically without digging deeper into the meaning of each historical event [24]. This also has an impact on the learning outcomes and abilities of pupils who are less than optimal because it makes pupils try to memorize chronicles without understanding why an event occurs.

Historical learning when developed well by teachers in each school. It can open up opportunities pervasive for each pupil to analyze and build an appreciation of the whole sphere of human life is not only limited in the STEM education fields even in terms of the interaction between human beings. Therefore, from that, pupils are required to inquire actively and learned not just passively listening and absorbing all the knowledge. Significantly, historical understanding expects pupils to connect further in solving the problem of history instead of hearing and reading stories of history. Narrated and meaningful literate, think in causal relationships, interviewing the perpetrators of the history of the community, analyzing documents, photos, newspaper historical, historical records at museums and historical sites, and build the line time and each narrative history. Essentially, the activities are also the basis for which the STEM approach is applied [12].

STEM education approach can guide teachers to enter a new world in learning history. The process of learning history in the classroom can be a new way for pupils to be able to maximize their potential in increasing their critical thinking skills. Because, the purpose of STEM education approach is following with the skills expected in learning history, namely historical thinking skills which require critical thinking skills. In history learning that uses the STEM approach, teachers must be able to invite pupils to learn about how they become an engineer who can solve problems that exist in the world from studying history [25]. The teacher can make the problem-based learning (PBL) and project-based learning (PjBL) in real-life learning, not only limited to the memorizing the past events. The best practice how to implement the STEM, which integrated with the history learning is from SMAN 8 Tangerang. The history teacher asks the pupils for three weeks to do research and they did not have any material in the classroom, but they did a historical research project in the nearest area. Hence, the teacher can measure historical thinking skills using project learning.

According to Bettelheim [26], studying history is "rich food for their imagination, a sense of history, how the present situation comes about." History will broaden the pupil's experience, as stated by Phenix [27], "a sense of personal involvement in exemplary lives and significant events, an appreciation of values and vision of greatness." History connects pupils with their roots and develops a sense of belonging. To achieve

it, the historical material that will be given to pupils is developed. Based on two main foundations, in particular historical understanding and historical thinking skills.

Through the history learning pupils gain a deep understanding of scientific patterns to seek understanding of the world in which humans live and do things better/efficiently; understanding of what humans have obtained, including the development of science and technology that creates change. Through history, pupils begin to understand the political climate that has developed in the local community to the world community. What is important at the core of this problem is how to understand democratic values. Through history, a deep understanding of society is obtained, differences and changes in family structure patterns, differences in the roles of men and women, the roles of children and childhood life, in various groups, and the relationship between individuals and groups [28]. However, what is still happening in the field is that history teachers even teach history in a boring way and do not cause pupils to think critically. It because the history teacher in Indonesia still limited to conveying facts without inviting pupils to analyze every historical event.

3.1. STEM approach in history learning

To implement the STEM approach in history learning, every history teacher should be able to integrate historical content with the STEM education approach [29], [30]. It is possible because in historical material, particularly in the material of Indonesian History, starting with Base Competencies at the beginning of grade 10 has entered material on ancient human technology. It can be related to the STEM education approach regarding how early humans were able to develop technology according to the needs of their time.

Still, in 10th-grade, there is material about vessels and the Iron Age. It can be related to the STEM education approach, and how history teachers can lead pupils to analyze how early humans at that time knew that iron had a melting point at a specific temperature. As well as much more suitable material in terms of mathematics about how the ability of the ancient Indonesian people to make Borobudur temple, of course, apart from requiring technology, it also requires high mathematical abilities so that it is capable of precision. So far, when history teachers teach about Hindu-Buddhist civilization in Indonesia, it is still limited to the fact who founded it, and at whose time it was finished. However, it does not refer to how humans at that time completed it with their knowledge. However, this is still difficult for teachers because of the limitations of teachers to develop learning materials outside the textbooks provided by the government.

To carry out the STEM education in history learning, teachers need to involve pupils on relevant problems with the real world so the pupils feel importance to learn history [31]. In that way, pupils get more motivation from studying history, not just remind of the past event. Teachers should be able to invite pupils to be more active and arouse their curiosity by involving them in research activities, so they will get facts from their activities not through teacher lectures. The material for grade 10 for the example, it is very clear about the steps of research in history, this is following STEM education approach which requires pupils to work according to scientific stages [32]. The teacher must be able to make pupils interested in doing mini historical research, for contemporary events that pupils can still encounter.

The expected skill in history learning is historical thinking skills. Historical thinking skills expect the pupils who learn history to be able to have the ability in chronological reasoning which is historical causation where historical learning is not meant to memorize. But, examines how and why an event can occur, this is aligned with the STEM education approach which in STEM participants pupils are asked to be able to read how technology and science can be created according to the needs of their time, that way, historical Thinking can encourage pupils who have extraordinary reasoning power.

Learning history can open opportunities for pupils to analyze and develop analyze of human activities and their relationships with others. To make that atmosphere, the pupils must be conditioned to ask questions actively and learn not only passively absorb information in the form of facts, names, and year numbers as truth. There are five forms of historical Thinking that can develop historical thinking skills are carried out using the STEM education approach, namely chronological thinking, historical comprehension, historical analysis and interpretation, historical research capabilities, and historical issues analysis and decision making [33]–[35]. By learning history, pupils are also indirectly learning the skills that are needed by everyone in the twenty-first century.

The goal of STEM is to create learner can compete and ready to work the fields practiced. The Hannover's study shows that the main objective of the STEM approach is to demonstrate holistic knowledge [36]. The STEM approach requires a learning approach to be carried out with an approach that can bring pupils to use their potential in critical thinking. In the 2013 curriculum in Indonesia, several learning models have been facilitated that refers to that direction, namely PBL and PjBL models, it remains how educators can implement it in teaching history in the classroom [37], [38].

One of the goals of STEM is for pupils to have literacy skills, master in 21st-century competencies and STEM workforce readiness, be interested and actively involved in learning, and make connections [5]. It can all be done in history learning because these abilities are also goals in historical thinking skills that must

be achieved by pupils after learning history. But, historical thinking skills in history learning has not been done up by a history teacher intensively [39]. Yet, according to previous research that STEM education significantly improve pupils' critical thinking skills when compared to conventional learning processes [40].

In a multidisciplinary approach, that combines science, technology, engineering, and mathematics, the history learning needs to involve environmental issues which appropriate to do with problem based learning PBL [41]. Integration of PBL with STEM education in history learning can actualize environment literacy and creativity. STEM approach enhancement will form the character of pupils who can recognize a concept or knowledge (science) and apply that knowledge with the skills (technology) they master to create or design a method (engineering) with analysis and based on mathematical data calculations (math) to find a solution to solving a problem so that human work becomes easier [42]. Schools need to provide recommendations to teachers to gain knowledge, implement and develop STEM education in schools. Building historical thinking skills can only be developed if pupils are often asked to do HOTS. One of the most effective ways to build pupils' historical thinking skills is by applying the right method, in particular method that can invite pupils to think critically [43].

The success of learning history to improve historical thinking skills must be supported by teachers and pupils. Pupils should have high interest and motivation to learn [44], [45]. The teacher must also master in historical material and can teach the material using the learning models. The purpose of teaching history will be reached and the impact also on the achievement of the learning outcome. The five forms of historical thinking skills make history learning more meaningful than just memorizing a series of facts. The key to realizing history learning as referred lies in the teacher as the "life-curriculum". Changing the material-based learning paradigm to competency-based learning is a necessity. Mastery of the various approaches and methods of learning from the teachers are needed to facilitate meaningful learning. Through this meaningful learning, it is hoped that pupils can develop into individuals who can play an important role as individuals, as citizens of society, and as citizens of the world.

4. CONCLUSION

History teachers still use conventional learning approaches in the learning process that always make pupils learn at a low skill level. Four schools that were subjected in this study, only history teachers at SMAN 8 Tangerang have tried to apply STEM education in learning, although learning is still not optimal because not all aspects of historical thinking skills have been touched. Nevertheless, SMAN 9 Tangerang, SMKN 6 Kab. Tangerang and SMKN 7 Kab. Tangerang still apply lotus online trading system LOTS based historical learning and still slightly integrate STEM in their learning, it happened because the demands of curriculum and formative test to be carried out are still limited to low-level objective tests. Based on the description of historical thinking skills for pupils in the previous discussion, STEM integration in historical learning is very important for every teacher. It is illustrated from the pupils' learning outcomes that teachers who have done learning with STEM show that pupils' historical thinking skills are enhanced.

The implication of this research that teachers should be able to integrate STEM approach into history learning, so that pupil can improve their historical thinking skills and have an effect on developing critical thinking. Critical thinking skills are the characteristics of global citizens, multicultural and democratic societies, so that they will equip pupils to be ready and aware of facing academic, civic and social challenges in the future. Through the development of historical thinking skills in learning, it is hoped that later pupils will have the skills to review their environment more critically, determine their future, and influence decisions related to their fate. Pupils' social skills, comprehension of the cultural environment in which pupils live, and pupils' intellectual and emotional abilities when living in society can grow along with the high ability of pupils to think.

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