Journal of Education and Learning (EduLearn)
Vol. 18, No. 1, February 2024, pp. 236~243
ISSN: 2089-9823 DOI: 10.11591/edulearn.v18i1.20890

Enhancing historical consciousness in history education through integrating STEM approach and historical thinking skill

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Article Info

Article history:

Received Apr 2, 2023
Revised Sep 5, 2023
Accepted Sep 17, 2023

Keywords:

Historical consciousness
Historical thinking skill
History education
History learning
STEM education

ABSTRACT

The research explores the potential of incorporating science, technology, engineering, and mathematics (STEM) education approach and critical thinking to enhance historical consciousness. The study employs an ex post facto quantitative method, specifically a correlational design to analyse the variables. The research population comprises 425 students from diverse backgrounds in Banten Province schools that have implemented the STEM approach. A sample size of 202 students is determined using a predefined error rate. Data collection involves tests and questionnaires assessing historical thinking skills, STEM approaches, and historical consciousness. Statistical analysis, including partial and simultaneous multiple correlation tests, reveals a significant and very strong positive relationship between STEM approach, historical thinking skills, and historical consciousness. This suggests that the interplay of these factors enhances history learning and encourages a deeper understanding of historical events, promoting critical thinking, and historical consciousness. The study emphasizes the importance of integrating STEM methodologies into history education to provide students with a holistic understanding of historical events and their societal implications. Such an approach bridges the gap between STEM and history, fostering interdisciplinary collaboration and promoting informed and empathetic citizens. Future research should explore diverse samples, employ qualitative methods, and investigate curriculum designs and teaching strategies that effectively integrate STEM and history education.

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1. INTRODUCTION

History education in Indonesia is mandatory from elementary to high school, covering the country's independence movement, Dutch colonial period, World War II, and post-independence period. The curriculum aims to instill patriotism and national identity in students [1]. However, problems in history learning include lack of resources, unengaging teaching methods, narrow focus on a single perspective, and limited access to historical sites and monuments [2]. These issues can limit students' understanding of the past and its impact on the present, hindering their future success and engagement [3].

History learning should be interactive, engaging, and centered on critical thinking, analysis, and diverse perspectives [4]. It should be relevant to current events and real-world issues, fostering empathy and understanding [5]. Using hands-on activities and primary source analysis, history education promotes

informed decision-making, exposure to diverse cultures, and cultural understanding, ultimately fostering a more informed and engaged citizenry [6]. Memorization in history education is limited and does not develop critical thinking skills or historical consciousness. Students must analyze historical events, sources, and perspectives, using historical thinking skills like sourcing, contextualization, and corroboration. Integrating historical perspectives into science, technology, engineering, and mathematics (STEM) subjects deepens understanding of social and cultural contexts [7]–[10].

History education aims to promote a deeper understanding of the past and its impact on the present through teaching critical thinking skills, fostering empathy, and considering diverse perspectives. Memorization is a helpful tool, but a comprehensive approach requires students to develop historical thinking skills and consciousness to truly engage with and understand the past. History education with a STEM approach incorporates elements of STEM into the study of history. This approach can enhance history education by providing students with a deeper understanding of the technological and scientific advancements that have shaped our world, as well as the social and cultural context in which these advancements occurred [11]–[13]. The integration of STEM into history education can also promote critical thinking skills, such as data analysis and problem solving, and help students understand the interplay between science, technology, and society [14], [15]. This approach can also increase student engagement and motivation by making history more relevant and accessible and can prepare students for careers in STEM fields. History education with a STEM approach can provide students with a unique and interdisciplinary perspective on the past. This approach combines the study of STEM with the study of history, promoting a deeper understanding of the role these fields have played in shaping society and shaping the present. The following elements can be included in a STEM approach to history education [11], scientific analysis: using scientific methods and theories, students can gain new insights into historical events such as environmental change, disease outbreaks, and technological advancements. Technology integration: including maps, visualizations, and digital archives in history education can provide students with new ways to access and analyze historical sources. Engineering design principles and techniques can assist students in understanding the role of technology in shaping history and shaping the present. Mathematical analysis: using mathematical methods and models to understand complex historical events and patterns, such as population trends and economic development, can help students.

A STEM approach to history education offers a comprehensive and interdisciplinary understanding of the past and its impact on the present [16], [17]. Learning history with historical thinking skills involves analyzing and interpreting historical events and sources in a critical and informed manner [16]. These skills include sourcing, contextualization, corroboration, causality, and continuity and change [18]. By incorporating these skills into history education, students gain a deeper understanding of the past and its impact on the present [19], promoting critical thinking and historical consciousness abilities that can be applied to various subjects and disciplines. The goal is to encourage informed, critical, and engaged citizens.

2. METHOD

This study employs an ex post facto quantitative method. Ex post facto is one of the quantitative research methods used to explain cause-and-effect relationships between certain variables. In this method, the researcher has no control over the variables under study and does not have the ability to influence the events being observed. Researchers can only perform analysis of existing data to determine the relationship between the variables under study [20]. The research design used a correlational design, which aimed to find out the the relationship between two or more variables. The data collected consists of two variables, namely STEM approach (X_1), historical thinking skill (X_2), and historical consciousness (Y).

2.1. Population dan sample

The population under study consisted of 425 students drawn from three different schools in Banten Province. These schools, namely Senior High School 4 Tangerang, Senior High School 8 Tangerang, and Senior High School 9 Tangerang, were intentionally chosen due to their diverse student demographics, socio-economic backgrounds, academic performance, and the implementation of the STEM approach in their teaching processes. This diversity allows for a comprehensive analysis of the research questions, ensuring that findings can be generalized more broadly.

To determine an appropriate sample size, the researchers used the Isaac and Michael formula with a predefined error rate of 5%. This calculation resulted in a sample size of 202 students, as detailed in Table 1. The allocation of these samples to each school and class followed a random selection process, whereby students' names were drawn until the required number of samples for each school and class was reached.

Table 1. Research sample data

School	Class	Population	Determination population	Samples
Senior High School 4 Tangerang	X Social 1	36	$\frac{36}{425} \times 202 = 17.11$	17
	X Social 2	36	$\frac{36}{425} \times 202 = 17.11$	17
	X Social 3	35	$\frac{35}{425} \times 202 = 16.64$	17
	X Social 4	36	$\frac{36}{425} \times 202 = 17.11$	17
Senior High School 8 Tangerang	X Social 1	36	$\frac{36}{425} \times 202 = 17.11$	17
	X Social 2	34	$\frac{34}{425} \times 202 = 16.16$	16
	X Social 3	36	$\frac{36}{425} \times 202 = 17.11$	17
	X Social 4	36	$\frac{36}{425} \times 202 = 17.11$	17
Senior High School 9 Tangerang	X Social 1	35	$\frac{35}{425} \times 202 = 16.64$	17
	X Social 2	35	$\frac{35}{425} \times 202 = 16.64$	17
	X Social 3	34	$\frac{34}{425} \times 202 = 16.16$	16
	X Social 4	36	$\frac{36}{425} \times 202 = 17.11$	17
Total		425		202

2.2. Instruments

Data collection is carried out using tests and questionnaires as the instruments. The test instruments were used to collect data related to historical thinking skills, while questionnaires were used to uncover data on STEM approaches and historical consciousness. The historical thinking test instrument is in the form of multiple choices with five answer choices, namely a, b, c, d, and e option which include understanding, memory, analysis, and evaluation level. The respondents are expected to select an answer from the options provided, with the correct answer receiving a score of 1, and the incorrect answer receiving a score of 0. Meanwhile, the STEM approach and historical awareness questionnaire instrument employ the Likert scale model, which includes five alternative answers that include both positive and negative statements. Multiple-choice questions to assess factual knowledge or specific skills, as well as Likert scale questions to assess attitudes and perceptions about the STEM approach and historical awareness. This combination of evaluation methods allows for the capture of both objective knowledge and respondents' subjective opinions.

2.3. Validities dan reliabilities test

Validity test using content and constructs. The validity of the content is assessed by experts to measure the indicators of the variable achieved. The validity of the construct using the biserial point correlation coefficient formula [21]. While reliability uses Kuder Richardson 20 formula, the instrument is reliable if it has a reliability coefficient of > 0.6 [22]. The results of each of the STEM approach (X_1), historical thinking skill (X_2), and historical consciousness (Y) instruments are declared reliable because they have a reliability coefficient of > 0.6, so that all instruments are reliable and can be continued on hypothesis analysis and testing.

2.4. Data analysis

Data analysis involves the application of parametric statistical techniques, which are designed to examine hypotheses related to population parameters. To conduct this analysis, we employed the IBM Statistics SPSS 26 software. We utilized partial and simultaneous multiple correlation tests to explore the connections among STEM approaches (X_1), historical thinking skills (X_2), and historical consciousness (Y) within the context of history education. In this process, we employed the partial double correlation test for assessing relationships between pairs of variables and the double correlation test when examining relationships involving more than two variables simultaneously. However, before conducting hypothesis tests, it was essential to perform a descriptive analysis and preliminary tests to ensure that the data met certain prerequisites. These prerequisite tests encompassed evaluations for normality, linearity, and multicollinearity.

3. RESULTS AND DISCUSSION

3.1. Prerequisite test

The normality test in Table 2 shows that the data variance is normally distributed. Based on the results of the normality test analysis using the Kolmogorov-Smirnov model, the value of obtaining the STEM

approach variable was 0.200, historical thinking skill was 0.080, and historical consciousness was 0.200. Thus, the gain of each variable is greater than 0.05 (significance > 0.05).

Table 2. Normality test results

Variables	Kolmogorov-Smirnov[a]			Shapiro-Wilk			Description
	Statistic	df	Sig.	Statistic	df	Sig.	
STEM approach (X_1)	0.053	202	0.200*	0.971	202	0.000	Normal
Historical thinking skill (X_2)	0.059	202	0.080	0.968	202	0.000	Normal
Historical consciousness (Y)	0.052	202	0.200*	0.973	202	0.001	Normal

The findings from the linearity test, as depicted in Table 3, reveal crucial insights into the relationship between the STEM approach and historical thinking skill variables. The STEM approach variable exhibits a significant deviation from linearity, as evidenced by its substantial score of 0.796. On the other hand, the historical thinking skill variable scores 0.208, surpassing the threshold of > 0.05. This outcome suggests that there is a discernible linear relationship between the independent and dependent variables. The statistical significance of these results underscores the importance of considering both the STEM approach and historical thinking skill in understanding and analyzing their interconnected impact within the research framework.

Table 3. Linearities test results

Variables	F linearity	Sig.	Criteria	Description
STEM approach (X1)	1122.588	0.796	p > 0.05	Linear
Historical thinking Skill (X2)	1609.562	0.208	p > 0.05	Linear

The multicollinearity test results, as outlined in Table 4, reveal that both the STEM approach (X1) and historical thinking skills (X2) variables exhibit favorable values, with a tolerance of 1.000 (above the acceptable threshold of 0.10) and a variance inflation factor (VIF) of 1.000 (below the critical value of 10). These outcomes signify the absence of multicollinearity issues between the variables, indicating that they can be considered as independent contributors to the model without redundancy. The robust tolerance and low VIF values provide assurance that the inclusion of both the STEM approach and historical thinking skills in the analysis does not compromise the reliability of the regression model, reinforcing the validity of the study's results and the meaningful interpretation of the relationship between the variables.

Table 4. Linearities test results

Variables	Tolerance	VIF	Description
STEM approach (X1)	1.000	1.000	No multicollinearity
Historical thinking Skill (X2)	1.000	1.000	No multicollinearity

The hypothesis testing results in Table 5 indicate that there is a positive relationship between the STEM approach and historical consciousness, as evidenced by a partial value of 0.925 and a significance level of 0.000 ($p < 0.05$). Similarly, the relationship between historical thinking skills and historical consciousness is also positive, with a partial value of 0.940 and a significance level of 0.000 ($p < 0.05$). Consequently, it can be concluded that both the STEM approach and historical thinking skills exhibit significant relationships with historical consciousness.

Table 5. Partial correlation test results

Variable	Partial	Sig	Criteria	Description
STEM approach (X_1) towards historical consciousness (Y)	0.925	0.000	p < 0.05	Significant
Historical thinking skills (X_2) towards historical consciousness (Y)	0.940	0.000	p < 0.05	Significant

Table 6 is simultaneous multiple correlation test results reveal a strong simultaneous correlation among the STEM approach, historical thinking skills, and historical consciousness in the context of history education. This conclusion is drawn from the acquisition of a Sig. F change value of 0.000, which is below the threshold of 0.05 ($p<0.005$), and an increase in the R-value of 0.941. As such, it can be concluded that

there is a significant relationship between the STEM approach and historical thinking skills with historical consciousness.

Table 6. Simultaneous multiple correlation test results

Variable	R	R Square	Sig. F Change	Criteria	Description
STEM approach and historical thinking skill towards historical consciousness	0.941	0.885	0.000	$p < 0.05$	Significant and very strong

The study's results point to a highly significant and robust positive relationship between the STEM approach and historical thinking skills, as indicated by the high correlation coefficient and low p-value. This finding underscores the interconnectedness of these variables with historical consciousness. The elevated correlation coefficient implies a strong linear association, suggesting that as the STEM approach and historical thinking skills increase, historical consciousness also tends to increase. The low p-value further strengthens the significance of this relationship, providing statistical confidence in the observed connection. These results contribute valuable insights to the understanding of how the STEM approach and historical thinking skills jointly influence historical consciousness in the context of the study, emphasizing the importance of interdisciplinary perspectives in shaping a comprehensive understanding of historical awareness.

3.2. Discussion

Based on the findings of the simultaneous multiple correlation test, it's evident that there exists a significant connection between the STEM approach, historical thinking skills, and historical consciousness in the context of historical education. This suggests that these three elements complement each other and should be integrated into teaching to enhance the overall engagement and effectiveness of history education. The results of previous research explain that historical thinking and historical consciousness have a very close relationship [23]. The relationship between stem education and historical consciousness is complex, as they are two distinct fields of study [12]. However, stem education can support the development of historical consciousness by teaching critical thinking skills that can be applied to analyzing and understanding historical events and issues [11], [24]. Additionally, incorporating a historical perspective into stem education can deepen students' understanding of the social and cultural context in which scientific and technological advancements have occurred. There is evidence to suggest that STEM education can promote historical consciousness. By using a STEM-based approach to studying history, students can engage in hands-on projects, simulations, and data analysis, which can help them to better understand and retain historical events, figures, and concepts [11], [12], [25]. For example, students can use technology to create historical simulations or digital timelines, or they can use data analysis to understand patterns and trends in historical events [26], [27]. This approach also emphasizes critical thinking and problem-solving skills, which can help students to develop a deeper appreciation for historical events and their impact on the present.

The findings of our research are in alignment with the conclusions drawn by [28] in their study, wherein historical consciousness is identified as a significant factor that can be enhanced through the cultivation of historical thinking skills. There is a strong correlation between historical thinking skills and historical consciousness. Historical thinking skills, such as source analysis, context, and causality, are essential for understanding and interpreting the past, which is an important aspect of historical consciousness [16], [29]. Developing historical thinking skills enables individuals to engage with historical events and issues in a critical and reflective manner, leading to a deeper understanding and appreciation of the past and its impact on the present. Additionally, these skills can also be applied to contemporary issues and events, fostering a sense of empathy and cultural understanding [30].

There is a strong correlation between historical thinking skills and historical consciousness. Historical thinking skills, such as chronological reasoning, sourcing, contextualization, and corroboration, are essential for developing historical consciousness. These skills enable individuals to analyze and understand historical events, perspectives, and narratives in a nuanced and critical manner [31]. In turn, historical consciousness refers to an awareness and understanding of the past and its impact on the present, which is bolstered by the application of historical thinking skills. Thus, developing historical thinking skills is critical to fostering historical consciousness.

The relationship between STEM education approach, historical thinking skills, and historical consciousness is interdependent. A STEM education approach that incorporates historical perspectives can help develop historical thinking skills by providing context and background information for scientific and technological advancements. This type of education can also promote critical thinking and analysis by encouraging students to consider the social and cultural implications of technological innovations. On the

other hand, the development of historical thinking skills through the study of history can deepen students' understanding of the context in which scientific advancements have occurred, which in turn can enhance their stem education experience. Ultimately, both stem education approach and historical thinking skills contribute to the development of historical consciousness, as they both play a role in helping individuals understand the past and its impact on the present.

The relationship between STEM education approach, historical thinking skills, and historical consciousness is interrelated. A STEM education approach that incorporates historical perspectives and emphasizes the social and cultural context in which scientific and technological advancements occur can help develop historical thinking skills [32]. These skills, in turn, support the development of historical consciousness by enabling individuals to analyze and understand historical events and their impact on the present.

On the other hand, incorporating historical thinking skills into STEM education can deepen students' understanding of the subject and help them see the connections between STEM fields and the broader context in which they exist [30]. This integration of STEM and history can result in a more comprehensive understanding of both subjects and contribute to the development of historical consciousness. In summary, STEM education and historical thinking skills can both play important roles in fostering historical consciousness, and their relationship is mutually supportive.

The relationship between STEM education approach, historical thinking skills, and historical consciousness is interconnected. STEM education can support the development of historical thinking skills by teaching students to analyze and interpret data, think logically, and make informed decisions [32]. This in turn can aid in the development of historical consciousness, as these skills can be applied to historical events and narratives. Additionally, incorporating a historical perspective into STEM education can deepen students' understanding of the social and cultural context in which scientific and technological advancements have occurred, thereby promoting historical consciousness [17], [33]. On the other hand, the development of historical thinking skills can also enhance STEM education by providing students with a deeper understanding of the history of science and technology and its impact on society.

Teaching history using a STEM education approach involves incorporating scientific and technological concepts into the study of historical events and figures. For example, students could analyze the impact of innovations in transportation, communication, or medicine on historical events. They could also study the use of mathematical concepts, such as demographics and probability, in understanding the past. Additionally, students could engage in hands-on engineering and technology projects that help bring historical events to life, such as building a model of a historical structure or simulating a historical battle. By incorporating STEM concepts, students can gain a deeper understanding of history and its impact on the world today.

Promoting historical consciousness in history education is crucial for fostering empathy, understanding, and critical thinking skills. It helps individuals appreciate diverse perspectives, cultures, and histories, fostering a sense of identity, making informed decisions, addressing historical inaccuracies, and enhancing critical thinking abilities [34], [35]. This approach helps individuals engage with the world in an informed and empathetic manner, fostering a well-rounded society, and fostering creative management thinking for the future [36].

4. CONCLUSION

The study shows a strong correlation between STEM education, historical thinking skills, and historical consciousness, highlighting the potential of STEM methodologies to enhance historical awareness and scientific progress. Integrating historical perspectives in STEM education improves students' understanding of societal implications, promoting interdisciplinary collaboration between STEM and history educators. Teaching strategies focusing on analytical thinking and logical decision-making bridge the gap between STEM and history. The study's limitations include a specific sample of students from Banten Province schools, not considering all contextual variables, and complex causality. Future research should diversify the sample, track the evolution of STEM-historical thinking relationships, use qualitative methods, and investigate curriculum designs and teaching strategies that integrate STEM and history.

ACKNOWLEDGEMENTS

We would like to express our gratitude to the principals and history teachers at Senior High School 4 Tangerang, Senior High School 8 Tangerang, and Senior High School 9 Tangerang. Your assistance and valuable insights were critical in completing this research. Your commitment to education significantly improved the quality of this research. We are grateful for your support and collaboration.

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