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# Synchronous Learning with STEM and Economics Students' Critical Thinking Abilities

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**Abstract:** Increasing the quality of education has been a global challenge. The Indonesian government has responded this issue by reforming new curriculum that focuses on students' activities and critical thinking ability. This study aims at investigating the implementation of synchronous learning with STEM and its impact to students' critical thinking ability. This research adopted mixed methods, quasi-experimentally by using non-equivalent control group design research to gain a deeper understanding during experiment. The result of this work notes that synchronous learning with STEM slightly out performs the conventional learning activities and it can moderately illustrate the enhancing of students' critical thinking skills. The introduction of STEM in social sciences, primarily in an economics course, faces some challenges and adjustments as well as its implementation using live synchronous learning This result suggests to more comprehensive planning and materials in adopting STEM in social sciences as well as an effort to increase students' activities.

**Keywords:** Critical Thinking Skills, STEM Education, Economics Students, Synchronous Learning

## INTRODUCTION

Education has been thought of as a key factor in the development of human resources, and it has raised attention among scholars throughout the world to increase the quality of education (Meyer & Benguerna, 2019). Some researchers believe that education robustly affects the social and economic development of a nation (Saviotti et al., 2016; Nowak & Dahal, 2016). However, enhancing the quality of education has been a global challenge. In the Indonesian context, the government has responded by revitalizing the new 2017-curriculum that focuses more on students' creativity, problem-solving ability, and critical thinking ability. The development of critical thinking abilities enables students to become accustomed to facing challenges primarily in this fourth industrial era and solving problems by analyzing their own thinking to make choices and draw conclusions (Hafni et al., 2020).

Critical thinking abilities can be developed through learning with STEM. STEM is a learning approach that involves science, technology, engineering, and mathematics into one class or lesson that is based on connections between the subjects and understanding an existing problem (Martin-Paez et al., 2019; Wu & Rau, 2019). Some scholars agree that applying STEM can help develop knowledge,

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help answer questions based on the investigation, and can help students create new knowledge (Krajcik & Delen, 2019; Hue et al., 2020). In the STEM approach, students are re-quired to always be active in class, both hands-on activity and minds-on activity (Khalil & Osman, 2017). The use of technology and information is always needed in its application. Independent learning and learning based on the latest issues that occur in society are mandatory in implementing STEM (Thibaut et al., 2018).

The growing body of literature points out that adopting the STEM learning approach can help students improve their critical thinking skills (Mutakinati et al., 2018; Mater et al., 2010). Critical thinking is a reflective ability that concerns making decisions about what to believe and what to do next (Cottrell, 2017). The STEM learning approach is expected to produce cognitive activities that are useful to bring up students' critical thinking. Integrated STEM makes students play a role as the center of learning activities (Shahali et al., 2016). An approach using STEM can seek to bring up skills in students, such as the ability to solve problems and conduct investigations (Capraro & Slough, 2013).

Thinking ability aims to collect information, present ideas with promoting evidence, open-minded, and gather new information undergoing critical thinking skills. An individual who thinks critically will not promptly accept and decline enlightenment instead of seeking out a strong information to propose a correctness According to Firdaus et al. (2015), several indicators that show students' critical thinking skills, including: first, presenting primary clarification related to issues and collect basic to strong information. Accordingly, students can promote an initial idea and view-points as well as drawing a conclusion.

In addition, the critical thinking ability requires students' skills in the term of de-scribing, analyzing, generalizing, and providing a conclusion. Learning using critical thinking skills enables students to have ability in solving given issues. Furthermore, the ability to think critically invites students to comprehensively understand on how students seeking out thought that arise combined with new cognitive needed, and can determine the stages to address the problems. Engaging students' critical thinking skills means that the assessment is carried out fairly and objectively (Dwyer, 2017; Dolech et al., 2017).

The STEM approach in education must be integrated, starting with the identification of real problems that occur in the environment of students by using innovative-critical thinking and problem-solving abilities so that conclusions can be drawn as an effort to solve these problems. The economics subject covers how individual behavior (households, firms, and government) allocates their resources to gain benefits as well as economic welfare (Mankiw, 2020). Some courses in economics are also close to the daily socio-economic problems that need a comprehensive from various disciplines sciences approach to provide a greater win-win solution (Voordjik, 2009).

A large and growing body of literature has investigated the implementation of STEM in various subjects in the sciences (Akerson et al., 2018; Sagala et al., 2019; Bunyamin et al., 2020). Despite the heightening studies in whether or how STEM influences students' activities and critical thinking skills, however, the focus on social sciences is overlooked by scholars. Therefore, the contribution of this research is threefold. First, this work provides an insight into the current literature

by revealing the impact of STEM on students' critical thinking skills. Second, this study is the first to examine STEM in social studies, primarily in economics. Third, through an empirical examination of the impact of STEM and students' critical thinking skills, this study can inform the model and limit the implementation of this approach.

## METHODS

### Study Design

The research design applied in this study was a quasi-experimental design and used the non-equivalent pretest-posttest control type of experiment group design. This study employed two classes as a sample at a senior high school in East Java of Indonesia by paying attention to the equality. The two groups that have been selected as samples was divided into treated class and control group. The experimental class was conducted using the STEM approach, while the control class was provided solely through face to face using synchronous learning through Zoom meeting.

**Table 1.** Research Design

| | | |
|---|---|---|
| O1 | X1 | O2 |
| O3 | X2 | O4 |

Information
O1 = Pretest on the experimental group
O2 = Posttest on the experimental group
O3 = Pretest on the control class
O4 = Posttest on the control class
X1 = without STEM
X2 = adopted STEM

### Measurement

This experiment was implemented in the macroeconomics course on national income due to this material is appropriate with the STEM (Science, Technology, Engineering, and Mathematics). In the science material related to the concept of national income, namely, functions, types of approaches to calculating national income. The technology applied is integration in the form of media for searching and delivering material or presentation, Material engineering related to modeling three calculations of national income in which there is a mathematical element. In this work, we provided approximately ten multiple-choice and three questions combined with SOLO Taxonomy (structure of observed learning outcomes) for both classes to evaluate critical thinking abilities. The question items have been calculated for its validity and reliability, employing the Person Correlation and Cronbach's Alpha method, respectively. The posttest is provided after completing learning activities using synchronous with STEM. Additionally, we also adopted the N-Gain test to evaluate the different level changes of this experiment.

## RESULTS & DISCUSSION

This study uses a STEM approach tailored to the topic in the economics course, namely national income. The fundamental rationale is that this topic is highly relevant to STEM and involves various dimensions in analyzing, including science, technology, engineering, and mathematics. In the first stage, learning activities begin by providing perceptions about the factors that affect national income in everyday life. This apperception is also carried out by making complex economic simplifications through an assumption. The learning process carried out by the teacher uses a scientific learning approach, where students are given the opportunity to find and process the information they obtained independently.

In addition to providing general information about national income, the involvement of technology in this study is related to the process of delivering findings by utilizing technology. In the implementation that has been carried out, learning is carried out online, automatically the role of technology in discussions and presentations using technology. Integrated technology is related to the media used, such as synchronous and asynchronous. With synchronous media undergoing Zoom meetings, students who have been formed in groups carry out discussion activities and present discussion results on the topic of national income. For asynchronous, each group comments in a discussion forum that has been created by the teacher. As for engineering, in this case, students design a model related to three types of approaches to calculating national income, namely the expenditure approach, production approach, and the income approach, which in this case are integrated with mathematics. This is because, in order to be able to design a three-model approach to calculating national income, one must understand mathematically according to the standard formula.

In the experimental class and control class, before learning, questions were given a pretest, and after learning, questions were given post-test and had been validated. Table 2 informs the comparison between pretest and post-test among students.

**Table 2.** The Comparison Score of Experiment and Control Group

| **Information** | **Experimental Class** | | **Control Class** | |
|---|---|---|---|---|
| | Pretest | Posttest | Pretest | Posttest |
| Min score | 55 | 72 | 53 | 70 |
| Max score | 68 | 88 | 60 | 86 |
| Average | 61.03 | 80.48 | 59 | 78.92 |

**Table 3.** N-Gain Average for Students' Critical Thinking Ability

| **Information** | **Experimental Class** | **Control Class** |
|---|---|---|
| Highest gain | 17 | 17 |
| Lowest gain | 20 | 26 |
| Average gain | 19.45 | 19.92 |
| N-gain | 0.67 | 0.64 |
| Decision | Moderate | Moderate |

Note: N-gain is calculated by comparison the ideal score/average gain.

In general, Table 2 shows the average score has shown an increasing change. At the beginning, the average pretest score is about 61.03 and 59 for experimental and control group, respectively. After the STEM education is implemented, however, there it inclines slightly between experimental class and control group of students' critical thinking skills. In more detail, the comparison N-gain between experimental class and control group is approximately, 0.67 and 0.64, respectively (see Table 3).

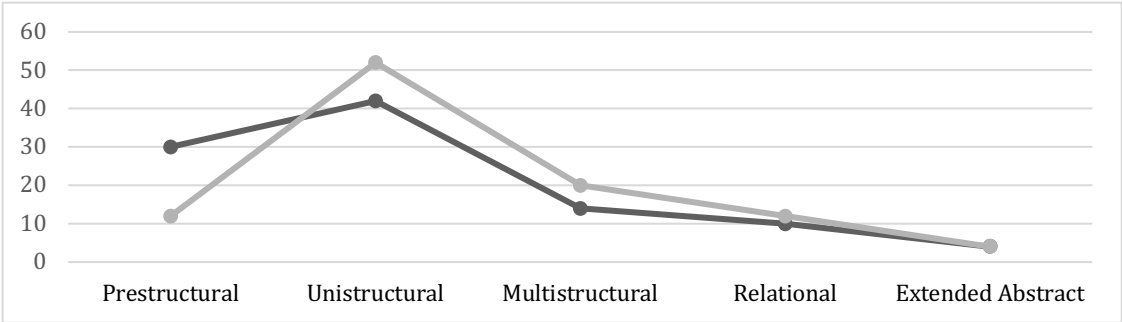


**Figure 1**. The Different Changes of Critical Thinking Domain

Figure 1 shows the domain of students' critical thinking skills following SOLO taxonomy. As the information, the treated students are provided in the grey line, while the control class is presented in the black line. From the figure, it can be known that the significant changes are experienced by pre structural and unistructural domain. In the beginning, it was approximately 30 percent of the population categorized pre structural group and about slightly higher than 40 percent in unistructural category. However, after STEM was adopted in the learning, the majority of students posits in the multicultural category with a percentage of more than a half. Additionally, there is remain stability in the domain of multicultural, relational, and extended abstract.

These findings indicate that the implementation of STEM moderately explains the changes in students' critical thinking skills. Unlike in the scientific studies that show a group change between the control and treated group, this project remarks that the implementation of STEM can slightly explain students' critical thinking abilities. The majority of prior studies found a robust correlation in implementing STEM for students' critical thinking abilities as well as learning achievements (Mutakinati et al., 2018; Mater et al., 2020; Siregar et al., 2020). Since this study is provided during the covid-19 pandemic, it drives learning activities from conventional to live synchronous learning. As a consequence, the interaction between educators and learners being insufficient. The teachers found difficulties in explaining the precise rules and instructions on how to elaborate STEM, as well as an inadequate internet connection. Second, the adoption of STEM for social sciences needs some adjustments primarily in the given topic to gain a great benefit for students to create their cognitive.

## CONCLUSION

In general, this study indicates that the implementation of STEM for economics courses moderately influences students' critical thinking skills. The introduction of

STEM in social sciences, primarily in an economics course, faces some challenges and adjustments as well as its implementation using live synchronous learning. However, the adoption of STEM in economics received a positive response from both educators and learners as an attempt to enhance students' critical thinking skills. Considering some constraints in this project, we suggested applying STEM during a normal condition when the materials and instruction provided appropriately to the students. Additionally, the materials used should be considered carefully that covers science, technology, engineering, and mathematics in its analysis. Lastly, linking ideas across disciplines is challenging when learners have little experience on the relevant topics. Also, students do not naturally implement their disciplinary knowledge in integrated contexts study.

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