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# WHAT DO TEACHERS THINK ABOUT CRITICAL THINKING SKILLS DEVELOPMENT IN STEM PROJECT?

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## Abstract

The research aims to investigate the teachers' perception of critical thinking development using Science, Technology, Engineering, and Mathematics (STEM) projects. This study was a descriptive study conducted by survey method where the population of this study consisted of 44 teachers from five regions of three countries in Southeast Asia. It used a set of questionnaires as a tool for collecting data. The results of this study showed that most of them had a proper perception of critical thinking development using STEM projects. Teachers in lower secondary schools are extremely confident in their capacity to teach STEM subjects and foster critical thinking in their pupils through STEM project-based learning activities. This number, however, turned out to be on par with upper secondary teachers, who all responded that they believed STEM projects may assist students to develop their critical thinking skills. This was because teachers in both upper and lower secondary schools had projects in science lessons. Teachers did not have high hopes that the STEM projects they created had to be completely new. Different things are found in teachers at colleges where they expected STEM projects that were made not based on project recipes found on internet pages. These findings could be insight for teachers on how to formulate and conduct the STEM project to foster students' critical thinking.

Keywords: College level, Critical thinking, Elementary level, Secondary level, STEM project.

## 1. Introduction

Critical thinking is involved in 21st-century skills because many experts believe that critical thinking skills can build the students' competencies strongly [1, 2]. It needs to be taught to students at every level of education because it can prepare them to be able to compete globally [3]. This critical thinking skill is in the first rank of skills needed in the 21st century [4]. It has a close relation to students' future career success which is also a positive outcome of Science, Technology, Engineering, and Mathematics (STEM) learning. The findings showed students who thought critically were able to analyse a problem scientifically and were able to solve the problem. Many researchers reported that students who have critical thinking skills are activated problem-solver [5]. They can give solutions to real-life problems and make decisions in solving a problem properly [6]. Researchers reported that students who have critical thinking skills can find solutions to a problem encountered in their daily life by using an inquiry-based learning strategy, which is a student-centred approach that stimulates students to conduct reasoning scientifically, think critically, and solve problems. Other researchers find the importance of critical thinking skills to the fundamental skills needed in the world of work. Good critical thinking skill is a foundation of multiple skills such as communication and collaboration skills, global awareness, mastery of technology, life, and career skills, learning skills, and innovations that can be developed by using problem-based learning [4].

Students with good critical thinking can analyse, synthesize, and evaluate information and then interpret it in making a decision and solving a problem [7, 8]. A project is needed to construct and connect concepts and materials in building critical thinking and problem-solving skills [7-9]. The number of strategies used to develop critical thinking skills indicates that critical thinking skills must be taught to students because of the positive impacts on students cognitively and effectively. So, it required a learning approach that can accommodate those skills. Among them is by involving students in projects that involve contextual problems in everyday life. The project that can be developed in teaching is by integrating STEM learning. STEM education is believed as a learning approach that trains students to learn STEM in building competencies, problem-solving, and being tolerant [5, 10].

Critical thinking skills in STEM need to be developed in teaching 21st-century students. And it demands 21st-century teachers to have critical thinking skills and also has a comprehensive understanding of teaching by using STEM projects. Thus, teachers have to be able to think critically before developing appropriate learning and before choosing learning strategies that can encourage the development of students' critical thinking. Providing an in-depth critical thinking process requires skilled teachers along with unique student-directed pedagogy [11].

Teachers take a big role in implementing STEM learning to help students to reach their ability to create and develop products and apply high-order thinking skills one of them is critical thinking [12]. Teachers need to understand the role, the application, and the concept of STEM, especially in solving problems that students encounter often in their daily life, it requires critical thinking skills in it [13]. Developing critical thinking skills through STEM projects needs a teacher who has the required knowledge, skills, and dispositions for practicing STEM projects and developing students' critical thinking skills [14].

Prior studies [8, 9,11, 15] have mostly focused on how teachers may encourage students' critical thinking using a variety of project techniques, including STEM. Few studies, however, have looked at how teachers see the growth of critical thinking through STEM projects. Also, the majority of earlier studies on STEM have always been student-centred rather than teacher-centred. Research using individuals from different nations and educational levels is uncommon. Research using the survey method to investigate teachers' perceptions of developing critical thinking through STEM projects across teaching levels has not been explored in depth. According to the explanations above, teachers' understanding of developing critical thinking skills by using STEM projects is important. It affects the results of teachers' teaching in STEM projects for developing students' critical thinking skills. All those things indicate that this research is crucial to be done because not many researchers have conducted research that takes up teachers' perceptions of critical thinking in STEM projects which is important. The results of this study can be used to determine whether teachers in Thailand, the Philippines, and Indonesia have been able to apply STEM projects to develop critical thinking skills or still need direction and deeper insight to implement them in learning.

The purpose of this research is to find out the teachers' perceptions of the development of critical thinking skills in STEM project activities. It also investigates teachers' beliefs to develop the skill. This research is using a descriptive method. The sample data of this study were taken from three countries in Southeast Asia. They are from Thailand, the Philippines, and Indonesia. They were chosen by purposive sampling technique. The data obtained from this research is to find out how deep the teacher's understanding of critical thinking skills is in STEM project activities. The research is unique in that it uses a purposive sampling method to choose participants from a variety of nations and educational levels. The method of choosing reduces research bias.

## 2. Methods

This research is a descriptive study conducted by survey using a questionnaire as a tool for collecting data. The data were collected from teachers in 3 countries in Southeast Asia. The samples of this research are taken by purposive sampling. They are 44 teachers from Mindanao - Philippines; South Luzon - Philippines; Yala - Thailand; East Java - Indonesia, and West Java - Indonesia. The complete information can be found in Table 1. The instrument of the study that was used was a set of questionnaires. The questionnaire consisted of two parts. It contained information about teachers' STEM teaching efficacy beliefs and the teachers' belief to develop critical thinking skills through the STEM approach. The questions were responded to by rating each statement on a 4-point Likert scale. They were 1 for strongly disagree (SD), 2 for disagree (D), 3 for agree (A), and 4 for strongly agree (SA). To get detailed information on the questionnaire responses, the research also used the unstructured interview.

## 3. Results and Discussion

Table 1 displays the variety of the research samples where it was discovered that teachers' perceptions were only differentiated by the level of their teaching site. Teachers at different grade levels believe they are equipped to instruct students in STEM subjects efficiently which could be seen in Table 2. Additionally, they

assume that they can effectively oversee STEM experimental operations to generate novel items. Teachers think they may engage students in learning that are focused on creating novel products. Besides, the majority of teachers agree that STEM projects can help students develop their critical thinking abilities. Teachers claim that STEM projects and critical thinking go hand in hand. Other thinking abilities, such as creative thinking, can be developed through STEM project activities. Teachers believed that critical thinking should base on real-world applications. Activities in STEM projects could accommodate those needs because they prepare students to survive in global competition [10, 15, 16]. The study of the survey's results reveals an interesting finding: teachers think STEM project activities are successful when they employ a local learning strategy that takes into account the needs of the students. These findings are also supported by another 0research [6, 8, 9]. The teacher is confident that if this approach is used, students' critical thinking abilities will grow rapidly.

**Table 1. Research sample information.**

| Characteristic | Category | Teachers | Deviation Standard |
|---|---|---|---|
| **Age** | 21 - 25 | 9 | 4.082483 |
| | 27 - 32 | 10 | |
| | 33 - 38 | 8 | |
| | More than 39 | 17 | |
| **Gender** | Male | 9 | 18.38478 |
| | Female | 35 | |
| **Teaching Level** | Elementary | 15 | 3.162278 |
| | Lower secondary | 8 | |
| | Upper secondary | 9 | |
| | College | 12 | |

The fact that teachers at the upper secondary level are quite confident in their ability to teach STEM and develop students' critical thinking skills through STEM projects is another intriguing finding from Table 2. This is apparent from the acquisition of a 0% response. According to the findings of interviews with many upper secondary teachers, the chemistry classes they have so far been using have been project-based. The teacher believes that STEM project helps students to develop their critical thinking. Researchers also argue that the skills that can be developed by STEM projects are finding practical solutions to real-life problems, designing products, engaging in high-level thinking, mastering technology, improving communication skills, and engaging in critical and creative thinking [17-20]. One of the inventive devices produced by the students, according to them, was an ice producer that capitalized on the cooperative qualities of solutions, specifically freezing point depression. The ingredients are also straightforward: ice cubes, rocky salt, and cake tins are used as containers. Although the product is not innovative, it is clear from its manufacturing that the students made a concerted effort to measure the quantity of salt and ice used so that the time it took to make ice was reduced.

Aloe vera, betel leaf extract, and 70% alcohol-based hand sanitizer are other goods created by upper secondary students. There is also an engineering design procedure involved in creating this hand sanitizer. Students believe that excessive

hand sanitizer use creates hand wrinkles. They believe that other components that are natural or derived from nature should be used in place of the glycerine that is included in hand sanitizers. They must correctly extract the aloe vera and betel leaves and determine the precise composition. To make sure the chemical content is kept appropriately maintained, this is done.

**Table 2. Responses on teaching critical thinking through STEM project.**

| Teachers' Responses | Elementary School | Lower Secondary | Upper Secondary | Collage |
|---|---|---|---|---|
| **Personal STEM Teaching Efficacy Beliefs** | | | | |
| **Strongly Agree** | 21.30% | 13.89% | 30.56% | 30.00% |
| **Agree** | 37.96% | 44.44% | 36.11% | 30.00% |
| **Disagree** | 22.22% | 26.39% | 33.33% | 26.67% |
| **Strongly Disagree** | 18.52% | 15.28% | 0 % | 13.33% |
| **The Belief to Develop Critical Thinking Skills through the STEM Approach** | | | | |
| **Strongly Agree** | 31.25% | 56.56% | 48.87% | 42.50% |
| **Agree** | 46.88% | 32.82% | 51.13% | 17.50% |
| **Disagree** | 8.33% | 1.56% | 0 % | 8.75% |
| **Strongly Disagree** | 13.54% | 9.06% | 0 % | 31.25% |

The majority of teachers at the college level disapprove least of those who can impart critical thinking skills through STEM projects. After conducting interviews, it was discovered that this occurred because college-level teachers believed that if the concepts developed to create original items were copies, then this approach was ineffective for instructing students in creative thinking. This is based on their discovery that product development ideas may be found online. One of the college-level teachers provided an ideal example of the flood-detecting device idea created by students that are reportedly also provided online.

In comparison to teachers at other levels, lower secondary school teachers are more likely (56.56%) to be able to develop their students' critical thinking abilities through STEM projects. According to the findings of interviews, they also applied a local knowledge or indigenous knowledge approach in this STEM project. The teacher helps the students construct kites. Students are given the task of building kites that can fly. Although students have enjoyed kite-making services, they do not comprehend the fundamentals. The STEM project provides students with an entertaining approach to learning about scientific principles.

Concerning their conviction that teachers help students develop their critical thinking abilities through STEM projects, elementary teachers have the lowest levels of confidence (31.25%). This is so that students do not receive excessive guidance at the elementary school level, as some teachers believe. Practical rules like recipes are used to carry out practical actions. The teacher is unaware that elementary school students genuinely possess talents that may be enhanced in the following development zone. These types of teaching methods may truly consider the broad range of student skills.

Critical thinking skills have an important role in applying the engineering design process [21]. The Accreditation Board for Engineering and Technology (ABET) even takes notice that in engineering curricula, generic engineering

competencies (soft skills) require critical thinking skills [22]. Critical thinking is important for students studying engineering, as it helps them in performing a task and enables them to reflect, question, and ground abstraction in reality.

The engineering design process integrates various approaches and perspectives, such as critical and creative thinking, in-depth and holistic insight, and procedural and conceptual knowledge to develop a solution [23]. These aspects also help students think logically and analytically. When students are tasked with making hand sanitizer, they don't randomly add materials. Instead, they follow a series of steps, including identifying the problem, brainstorming, designing, building, testing and evaluating, redesigning, and sharing the solution. These steps can be repeated until the engineer is satisfied with the results, and they contribute to a strong understanding of the fundamental concepts [19, 24-26].

Teachers at all educational levels in Thailand, the Philippines, and Indonesia share a strong view that STEM projects can help enhance students' performance [27, 28], particularly in terms of critical thinking abilities. However, executing these projects may present various challenges that can be addressed through local learning strategies, such as leveraging local knowledge content [29]. Therefore, the effectiveness of STEM projects is contextual. The perception of STEM projects and critical thinking does not significantly differ based on the gender and age of teachers. However, the teaching level of the teacher does impact how they approach promoting or fostering critical thinking through STEM projects. Further investigation into this area would be intriguing, especially considering the emphasis on cognitive psychology traits, learning cultures, and student learning environments among teachers in Southeast Asian nations, particularly Indonesia. These findings can provide valuable guidance to teachers on designing and implementing STEM projects that promote students' critical thinking skills.

## 4. Conclusions

The findings of this study demonstrated that nearly all Indonesian, Filipino, and Thai teachers had an accurate understanding of how STEM projects may help students enhance their critical thinking skills. Lower secondary school teachers are very confident in their ability to teach STEM and develop students' critical thinking abilities through STEM project activities (56.56%). This figure, however, turned out to be no better than teachers at the upper secondary level, who all stated that they thought STEM projects may help students strengthen their critical thinking abilities (48.87% and 51.13%).

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