Higher-Order Thinking Skills Through Problem-Based Learning Model Integrated with STEAM (Science, Technology, Engineering, Arts, and Mathematics) Approach in Solve-problems SPLTV (Three-Variable Linear Equation System)

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***Abstract*—This Research will describe how students' high-order thinking skills through the problem-based learning model solve SPLTV questions. This research is mixed method research, namely the existence of quantitative research and reinforced by descriptive qualitative research which aims to determine: 1) high-level thinking skills at the level of analysis. 2) knowing the thinking ability of the evaluation level. and 3) know the ability to think at a higher level of creation. This research was conducted in senior high school SMAN 1 Jember Class X.9 with a total of twenty-nine students. The results showed that: 1) Subjects at the level of analysis were only able to outline and solve story problems related to SPLTV using a technology approach. 2) Subjects at the evaluation level can outline and solve problems, and check and conclude SPLTV questions related to technology and science. 3) Subjects at the creative level can outline, solve problems, check, conclude, and can compile and generalize something new related to SPLTV questions with the STEAM approach.**

Keywords*—*High Order Thinking Skills Problem Based Learning, STEAM, and SPLTV

I. INTRODUCTION

Human resources in the era of globalization require individuals to have certain thinking abilities. Among them is the ability to think critically in responding to a problem, and also for each individual to be able to design or create something new or what is called the ability to think creatively. These three skills are recognized as higher-order thinking skills. The ability to think at a higher level is an internal ability understand, find a solution to a problem in a variety of ways for students to facing the demands of competence in the 21st century, one of which is that students are made to be more critical, creative and so that students can face complex situations in everyday life. Creative thinking entails the ability to analyze and break down existing problems. Complex human thinking patterns, as stated by Costa (1985), encompass problem-solving, decision-making, critical thinking, and creative thinking. This concept is applicable in the realm of education, particularly in training students in higher-order thinking. Musrikah asserts that many countries integrate higher-order thinking skills as an integral part of classroom learning processes. In the context of mathematics, students possess diverse abilities when it comes to comprehending and solving mathematical problems [1].

According to Annuru et al. (2017:137), higher-order thinking skills involve the ability to combine several cognitive processes, including analysis, evaluation, and creation of what has been learned. To prepare for this, educators must foster a learning culture that enhances higher-order thinking skills in the process of learning mathematics. Mathematics education holds characteristics where the present teaching approach often focuses on monotonous learning styles, communication is one-directional, and teaching solely relies on textbooks [3]. Consequently, this leads to students' stagnant low-order thinking skills. Moreover, mathematics instruction is often viewed as intimidating, requiring critical thinking and reasoning processes for students to comprehend [4].

Out of various teaching methods, problem-based learning is well-suited to develop higher-order thinking skills. Kardi and Nur state that problem-based learning is effective and capable of teaching higher-order thinking stages. The influence of teaching strategies on higher-order thinking skills, as posited by Ulfa (2013), shows that the application of problem-based learning strategies positively affects the enhancement of higher-order thinking skills. Bloom (2002) outlines six levels to assess higher-order thinking skills, ranging from low-order thinking processes such as knowledge, comprehension, and application to high-order levels like evaluation and creation. Indicators for higher-order thinking skills employed as guidelines for this research are: 1) Analysis, 2) Evaluation, and 3) Creation. One approach to enhancing higher-order thinking skills in students is through the utilization of problem-based learning models [5].

Problem-Based Learning (PBL) is a teaching method distinguished by presenting real-world problems as contexts to stimulate students in enhancing their critical thinking abilities. According to H.S. Barrows (1982), a PBL expert, Problem-Based Learning is a teaching model centered around problems used as the initial step to integrate knowledge. The Problem-Based Learning model encourages students to think critically and analytically, serving as a means for learners to generate ideas that align with technological advancements. A problem-based learning

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model that aligns with technological progress is integrated STEAM (Science, Technology, Engineering, Arts, and Mathematics) learning. Research congruent with this study has been explored by Mayasari (2015), Noma et al. (2016), and in an article by Sucipto titled "Developing High-Level Thinking Skills Using Metacognitive Strategy in Problem-Based Learning Model". It can be concluded that students are able to progressively develop their thinking skills, beginning with defining problems, seeking data, analyzing, and engaging in critical and logical thinking through the implementation of the Problem-Based Learning model (PBL) [6].

Based on the aforementioned issues, to delve deeper into high-level thinking skills through the Problem-Based Learning model, the researcher intends to conduct quantitative research strengthened by qualitative descriptive research, or referred to as a mixed-method approach, with the title: "High-Level Thinking Skills Through STEAM-Integrated Problem-Based Learning in Solving Linear Equations with One Variable Problems" [7].

II. METHODS

This research uses a mixed methods approach with a Sequential Explanatory design that uses data collection and quantitative data analysis in the first stage, and continued with data collection and analysis qualitative in the second stage, for strengthening results of quantitative research conducted on the first stage. Quantitative research involves collecting numerical data, while descriptive research provides a systematic description of the subject or object under investigation, presenting clear facts about the characteristics of the object under study. To achieve the research objectives, triangulation was used. John W. Creswell and Morse, J.M support the combination of quantitative and qualitative data collection techniques in research, because they complement each other effectively [8].

The qualitative component method uses interviews with selected subjects, while the quantitative aspect uses a One Group Pretest-Posttest design. Data analysis is based on Miles and Huberman's data analysis theory. According to Miles and Huberman as quoted in Sugiyono, the data analysis process in qualitative research is carried out directly and continuously until a valid answer is found or saturation is reached. Activities in the Miles and Huberman data analysis model include data reduction, data presentation, and drawing conclusions/verification [9].

The research flow is illustrated in the following diagram:

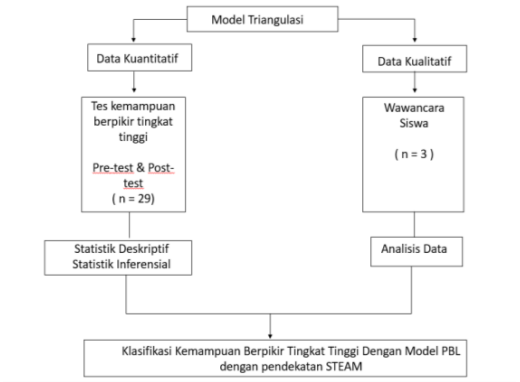

Figure 1. Triangulation Chart

III. RESULTS AND DISCUSSION

A. Results

The research findings demonstrate that students with higher-order thinking skills in solving problems related to Three-Variable Linear Equation Systems achieve the Analysis (C4), Evaluation (C5), and Creation (C6) levels. Based on their higher-order thinking abilities, students from Class X.9 can be classified into three categories: analyzing (C4), evaluating (C5), and creating (C6). In the analyzing classification (C4), these students can only identify what is known and asked in detail, as well as create an outline for the given problem in the question. In the Evaluation classification (C5), students can identify as per the indicators (C4) and can prove a problem with a proper solution following Polya's steps. Finally, in the creating classification (C6), students can construct a Three-Variable Linear Equation System (TVLES) problem using the STEAM approach, and they can also identify and solve the problem they have created effectively [10].

These results indicate an enhancement in students' higher-order thinking skills through the problem-based learning model integrated with STEAM. The percentage of higher-order thinking skills based on indicators is shown in Table 1.

Table 1 Percentage data of students with higher-order thinking skills based on indicators

Indikator Kemampuan Berpikir Tingkat Tinggi	Pretest		Posttest	
	Jumlah	Presentase (%)	Jumlah	Presentase (%)
Menganalisis (C4)	19	66%	6	21%
Mengevaluasi (C5)	6	21%	14	48%
Mengkreasi (C6)	4	13%	9	31%

Hypothesis testing was conducted to determine whether there is an influence of using the Problem-Based Learning model with the STEAM approach on students' higher-order thinking skills in solving problems. In this research, the Wilcoxon test was employed due to the non-normal distribution of data [11].

The hypotheses used are as follows:

- Ho (Null Hypothesis): There is no difference in the value of students' higher-order thinking skills before

and after being exposed to the Problem-Based Learning model with the STEAM approach.

- Ha (Alternative Hypothesis): There is a difference in the value of students' higher-order thinking skills before and after being exposed to the Problem-Based Learning model with the STEAM approach.

The criterion for the test result is that Ho is rejected if the value of Asymp.Sig is less than 0.05.

Tabel 2. Uji Non Parametric Test Wilcoxson

Test Statistics[a]	
	Posttest Kemampuan Berpikir Tingkat Tinggi - Pretest Kemampuan Berpikir Tingkat Tinggi
Z	-4,402[b]
Asymp. Sig. (2-tailed)	,000
a. Wilcoxon Signed Ranks Test	
b. Based on negative ranks.	

Based on Table 2, it is found that the sig value is 0.000, which is smaller than 0.05. Therefore:

- Ho (Null Hypothesis): There is no difference in the value of students' higher-order thinking skills before and after being exposed to the Problem-Based Learning model with the STEAM approach is rejected.
- Ha (Alternative Hypothesis): There is a difference in the value of students' higher-order thinking skills before and after being exposed to the Problem-Based Learning model with the STEAM approach is accepted.

Based on the descriptive analysis results, the mean value of students' pretest is 7.97, and for the posttest, it is 15.97. This indicates an improvement in higher-order thinking skills after receiving Problem-Based Learning with the STEAM approach. Therefore, it can be concluded that Problem-Based Learning with the STEAM approach significantly influences students' higher-order thinking skills in solving Three-Variable Linear Equation System problems for Class X [10].

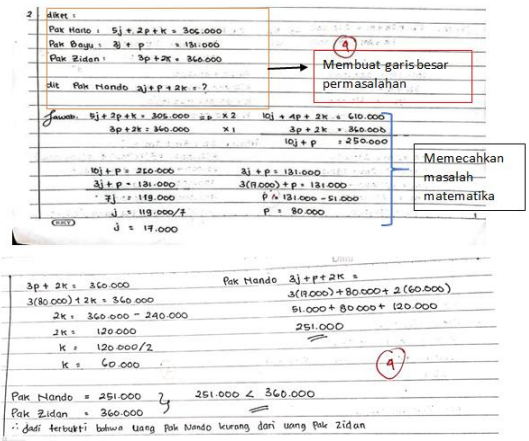

Figure 2. Problem Solving Results of Subjects

From the above figure, it can be observed that subjects in the Analysis level (C4) are capable of outlining problem-solving steps by identifying what is known and asked, and effectively solving mathematical problems. Subjects meeting the Evaluation level (C5) can outline the problem, solve mathematical problems accurately, and draw precise conclusions from problem-solving outcomes. Subjects meeting the Creation level (C6) possess the ability to outline, solve mathematical problems, make conclusions, and create new problems related to STEAM [12].

B. Discussion

a. Higher-Order Thinking Skills Analysis Level (C4)

In this research, the subject with higher-order thinking skills at the Analysis level (C4) is subject Y-05. Subject Y-05 can only write down what is known and asked, create an outline, and solve a problem correctly and relevantly. According to Yuniarti (2015:24), analysis (C4) is the individual's ability to identify and understand problems to find solutions to issues. This aligns with the research conducted by Rifdatul Karimah, indicating that students with analysis skills (C4) can comprehend problems, distinguish important and unimportant information, and explain each step in problem-solving [13].

Based on the fact that the posttest results show that 5 students can be classified at the Analysis level (C4), it is evident that Class X.9 students generally possess good analytical skills. This is demonstrated by an increase in the number of students classified at the analysis level between pretest and posttest.

b. Higher-Order Thinking Skills Evaluation Level (C5)

In this research, the subject with higher-order thinking skills at the Evaluation level (C5) is subject Y-04. Subject Y-04 can analyze information well, create an outline, solve problems, check the consistency in problem-solving, and draw accurate conclusions from problem-solving outcomes. This is consistent with Rifdatul Karimah's research thesis, indicating that students meeting the Evaluation level (C5) can identify important and unimportant information, understand different perspectives of a problem, choose problem-solving strategies, check the consistency and inconsistency of results, and assess the truthfulness of the final outcome [14].

Based on the existing facts, it's evident that only 9 Class X.9 students meet the Evaluation level (C5) in the posttest. This is because many students still struggle with grasping the concept, and some students lack diligence in the problem-solving process, such as making mistakes in the elimination process of Three-Variable Linear Equation Systems, resulting in inaccurate final outcomes compared to the question asked.

c. Higher-Order Thinking Skills Creation Level (C6)

In this research, the subject with higher-order thinking skills at the Creation level (C6) is subject Y-23. Subject Y-23 can plan and create a new problem and find a precise solution. This involves crafting a Three-Variable Linear Equation System problem with the STEAM approach, along with an accurate and correct solution [15].

This is consistent with Rifdatul Karimah's research, which states that subjects meeting the Creation level (C6) are students who can identify

important and unimportant information in a problem, understand different problem perspectives, determine appropriate problem-solving strategies, apply plans to alternative solutions found, and verify the truthfulness of problem-solving outcomes.

Based on the existing facts, the classification of students with Creation skills (C6) based on posttest results shows that many Class X.9 students possess Creation skills (C6), with a percentage of 52%. This is because the problem-based learning process requires students to independently solve problems, leading them to become accustomed to planning and composing problems. Consequently, the percentage of higher-order thinking skills at the Creation level (C6) reaches the highest among the other higher-order thinking skills [16].

IV. Conclusion

The conclusion that can be drawn from the research above is that the results of the Hypothesis test using the Wilcoxon test show an Asymp Sig value of 0.000, which means that the application of the Problem-Based Learning model with the STEAM approach has a significant effect on students' high-level thinking abilities in solving problems with three systems of linear equations. variables, especially in class X.9 students at SMA Negeri 1 Jember. The pretest and posttest results showed that 6 students demonstrated high-level thinking abilities at the Analysis level (C4). At this level, students can describe and solve problems accurately and correctly. 14 students showed high-level thinking abilities at the Evaluation level (C5). At the Evaluation level (C5), students can examine consistencies and inconsistencies and draw reasonable conclusions from the problem and also show that 9 students have high-level thinking abilities at the Creation level (C6). In the Creation level classification (C6), students can design or compose new problems and generalize problems that have been created accurately.

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