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STEAM (SCIENCE, TECHNOLOGY, ENGINEERING, ARTS, AND MATHEMATICS) APPROACH BASED ON PERFORMANCE ASSESSMENT OPTIMIZING HIGHER ORDER THINKING SKILLS

ABORDAGEM STEAM (CIÊNCIA, TECNOLOGIA, ENGENHARIA, ARTES E MATEMÁTICA) BASEADA NA AVALIAÇÃO DE DESEMPENHO OTIMIZANDO HABILIDADES DE PENSAMENTO DE ORDEM SUPERIOR

I Wayan Wiarta
Pendidikan Guru Sekolah Dasar, Universitas Pendidikan Ganesha, Denpasar, Indonesia
iwayan.wiarta@undiksha.ac.id

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Abstract: Lecturers often need help involving students who score less on the final assignment test. It shows that some students still need to achieve the learning objectives. In addition, there are still many students who need higher-order thinking skills. Thus, in the learning process, a learning approach is needed that can help students solve problems. This study aims to analyze students' higher-order thinking skills using a STEAM approach based on performance assessment. This study uses a quasi-experimental type of research (quasi-experiment). This study involved a sample of 82 students taken by cluster random sampling technique from 163 students who were distributed into 4 classes. The method used in collecting data is a test. The instrument used in collecting data is a question sheet in the form of a description test. This study used a nonequivalent control group design. The collected data were analyzed using parametric statistics with the t-test. The study results show differences in higher-order thinking skills between students who follow the STEAM approach based on performance assessment and those who follow conventional learning approaches. The results of the data analysis also showed that the group that followed the STEAM approach based on performance assessment had a higher-order thinking ability score higher than the average higher-order thinking ability of the group of students who followed the conventional approach. It was concluded that the STEAM approach based on performance assessment could improve students' higher-order thinking skills.

Keywords: STEAM Approach. Performance Assessment. Higher Order Thinking.

Resumo: Os professores muitas vezes precisam de ajuda envolvendo os alunos que pontuam menos no teste de tarefa final. Isso mostra que alguns alunos ainda precisam atingir os objetivos de aprendizagem. Além disso, ainda há muitos alunos que precisam de habilidades de pensamento de ordem superior. Assim, no processo de aprendizagem, é necessária uma abordagem de aprendizagem que possa ajudar os alunos a resolver problemas. Este estudo tem como objetivo analisar as habilidades de pensamento de ordem superior dos alunos usando uma abordagem STEAM com base na avaliação de desempenho. Este estudo utiliza um tipo de pesquisa quase-experimental (quase-experimento). Este estudo envolveu uma amostra de 82 alunos retirada pela técnica de amostragem aleatória por conglomerados de 163 alunos que foram distribuídos em 4 turmas. O método usado na coleta de dados é um teste. O instrumento utilizado na coleta de dados é uma folha de questões em forma de teste descritivo. Este estudo usou um projeto de

grupo de controle não equivalente. Os dados coletados foram analisados por meio de estatística paramétrica com o teste t. Os resultados do estudo mostram diferenças nas habilidades de pensamento de ordem superior entre os alunos que seguem a abordagem STEAM com base na avaliação de desempenho e aqueles que seguem as abordagens de aprendizagem convencionais. Os resultados da análise de dados também mostraram que o grupo que seguiu a abordagem STEAM com base na avaliação de desempenho teve uma pontuação de capacidade de pensamento de ordem superior maior do que a capacidade média de pensamento de ordem superior do grupo de alunos que seguiu a abordagem convencional. Concluiu-se que a abordagem STEAM baseada na avaliação de desempenho pode melhorar as habilidades de pensamento de ordem superior dos alunos.

Palavras-chave: Abordagem STEAM. Avaliação de Desempenho. Pensamento de Ordem Superior.

1. Introduction

The times are growing rapidly, and the tendency has changed towards a more digital one. Mastery of Science and Technology (IPTEK) is currently an important key in facing the challenges of the 4.0 industrial revolution era in improving the quality of life, equitable development, and quality of education (Sahin & Yilmaz, 2020; Santi et al., 2020; Syahputra & Maksum, 2020). The better the quality of education implemented, the higher the quality of human resources produced (Kebritchi et al., 2017; Saleha et al., 2022; Santi et al., 2020; Tempelaar, 2019). Education is a benchmark for the progress of a nation. Education can also force change toward better conditions (Mansouri & Moumine, 2017; Reis et al., 2021; Sarbini et al., 2021; Scull et al., 2020). Education gives students opportunities, hopes, and knowledge to live better.

However, along with the growing demands of the times, the education problem is becoming increasingly complex. One of them is the problem of the current quality of education, which still needs special attention from education experts because, until now, the quality of education still needs to be improved (Rahman et al., 2018; Adom et al., 2020; Moorhouse, 2020; O'Brien et al., 2020). In the survey, the quality of education issued by the Program for International Students (PISA), Indonesia is ranked 72 out of 77 countries (Nugrahanto & Zuchdi, 2019; Wagner et al., 2018). This data puts Indonesia in the bottom six ranks, far from neighboring countries such as Malaysia and Brunei Darussalam. The results of the PISA study stated that Indonesia scored 371 for reading, 379 for mathematics, and 396 for knowledge (science) (Suprapto, 2016; Susongko & Afrizal, 2018). The quality of education in Indonesia, which is very low, is judged by an education system that needs to be more modern and equipped with teacher competency (Falloon, 2020; May et al., 2020; Taylor & Ntoumanis, 2007).

In the era of Education 4.0, lecturers are not the main resource persons in the learning system but rather act as assistants, encouragers, and facilitators (Choi et al., 2014; Ramachandran & Rodriguez, 2020). It makes learning fun, and students can explore the concepts of knowledge they have (Nyatanga & Mukorera, 2019; Soper, 2017). The success of student learning outcomes can be seen from the level of understanding, mastery of the material, and ways of thinking. The higher the understanding and thinking skills of students, the higher the success rate of learning. However, what is happening now is showing that students' thinking skills could be more optimal; this can be seen that it is still difficult for students to ask questions and solve problems they face. Other research findings also state that many students still have low thinking skills (Chen et al., 2018; Darmaji et al., 2020; Hasyim et al., 2020; Ismail et al., 2018). Other studies also reveal that students' thinking skills are lowered due to less interesting learning activities (Amin et al., 2020; Korkmaz & Karakus, 2019; Perdana et al., 2017; Shaw et al., 2020; Weinstein & Preiss, 2017).

The observation results also show that lecturers are also often faced with a problem involving the presence of some students who score less on the final assignment test. It shows that some students still need to achieve the learning objectives. To find out whether learning objectives have been achieved, it is necessary to hold a performance test every time a material is presented in learning (Gotwals et al., 2015; Shaw et al., 2020; Tempelaar, 2019). This assessment provides feedback to lecturers to improve the learning process (Alshammari, 2020; Farrell, 2022; Lynch et al., 2021; Maulida et al., 2020). The need for assessment in learning to overcome the values not optimally obtained by students. Paradigm changes also affect the concept of educational assessment. The educational assessment concept shows a broader direction (Chen et al., 2022; Rastuti et al., 2021; Tempelaar, 2019). Assessment is to determine learning outcomes and how the learning process takes place (Barnard et al., 2021; Widana, 2017).

Thus, in the learning process, a learning approach is needed that can help students solve problems. One solution to this problem is applying the STEAM approach based on performance assessment. The STEAM approach is a method used to implement plans prepared as real and practical activities to achieve learning objectives (Arce et al., 2022; Kurnia & Nasrudin, 2022). This STEAM approach is an approach that refers to the five components of science, namely knowledge, technology, engineering, art, and mathematics (Bahrum et al., 2018; Wulandani & Putri, 2022). The STEAM approach is a learning alternative in facing the industrial revolution era 4.0, full of challenges.

The STEAM approach is a harmonious collaboration of scientific fields between problems that occur in the real world. The first STEAM approach promoted subjects that

needed new emphasis in schools (Ahmad et al., 2021; Herranen et al., 2021; Sartono et al., 2020). The STEAM approach implies that a program is the best that can be provided by science education in schools, but now from the STEAM approach, it is combined with the fields of design and innovation or adding music (Ahmad et al., 2021; Conradty & Bogner, 2018; Herranen et al., 2021; Jesionkowska & Wild, 2020; Sartono et al., 2020; Thuneberg et al., 2018). Then the Rhode Island School of Design coined the STEAM approach, specifically adding art to the mix. It is intended to show that good design elements and creative approaches are also incorporated into teaching so that it turns into STEAM, which stands for Science, Technology, Engineering, Arts, and Mathematics, which is a learning approach prepared to respond to the development of the industrial revolution 4.0 (Bayles et al., 2021; Bedar & Al-Shboul, 2020; Rahmawati et al., 2019). A collaborative STEAM-Based approach to performance assessment can optimize higher-order thinking skills.

Assessment is a systematic procedure used to collect information that can be used to reference student characteristics (Shaw et al., 2020; Tempelaar, 2019). Assessment is not only given to students but also a process that directs students to improve learning competence (Astalini et al., 2020; Gotwals et al., 2015; Jansen & Möller, 2022; Rus, 2019). The results of the assessment will be useful for students and lecturers. Students can find new learning strategies to improve their competence (Lynch et al., 2021; Sudana et al., 2020). Meanwhile, lecturers can apply new learning techniques regarding student weaknesses and strengths (Farrell, 2022; McVey, 2016; Sukenti et al., 2020). Several assessment techniques can be used to collect this information, such as formal and informal observation, paper and pencil tests, selected response tests, and student performance in assignments, research, projects, and oral questions. The assessment process includes several pieces of evidence that show the achievement of learning outcomes. This assessment is integrated with learning activities, referred to as a performance-based assessment.

Previous research findings also revealed that it is important to provide assessments to measure students' abilities after participating in learning activities (Irwanto et al., 2017; Maulida et al., 2020; McVey, 2016; Nurtanto et al., 2020). Other findings also state that the STEAM approach can improve students' learning abilities (Ahmad et al., 2021; Arce et al., 2022; Bahrum et al., 2018; Wulandani & Putri, 2022). Based on this research, the performance assessment-based STEAM approach can improve students' higher-order thinking skills. Student feedback is valued; successful and enduring STEAM programs ask for honest and constructive feedback. You can discover what works and what does not by asking students to participate in anonymous surveys

and opinion polls. There needs to be a study on the performance assessment-based STEAM approach that can improve students' thinking skills. This study aims to analyze students' higher-order thinking skills using a STEAM approach based on performance assessment.

2. Method

This study uses a quasi-experimental research type (quasi-experiment) with a control group but cannot fully function to control external variables affecting the implementation of the experiment (Sugiyono, 2015). This study aims to determine the differences in students' higher-order thinking abilities with STEAM learning oriented towards performance assessment and students who follow conventional approaches. This study involved a sample of 82 students taken using the cluster random sampling technique from 163 second-semester students of PGSD UPP Denpasar who were distributed into 4 classes. The learning approach is divided into the STEAM approach based on performance assessment and the conventional approach, which are independent variables. Meanwhile, the dependent variable is students' higher-order thinking skills.

The method used in collecting data is a test. To capture data on students' higher-order thinking skills, they use tests in the form of descriptions. The instrument used in collecting data is a question sheet in the form of a description test. The instrument grids used are presented in Table 1 and Table 2. This study used a non-equivalent control group design. The collected data were analyzed using parametric statistics with the t-test, which previously carried out prerequisite tests in data distribution normality and variance homogeneity tests. All data analysis using SPSS for Windows 16.0.

Table 1. Holistic Mathematics Performance Assessment Rubric Grid

No	Indicator	Score	Explanation
1	Demonstrate a precise and thorough understanding of concepts, and calculate correctly.		
2	Use tables, pictures, and graphs appropriately and thoroughly		
3	Using the right strategy, as well as the right and reasonable reasons		
4	Demonstrate a precise and thorough understanding of concepts, and calculate correctly.		
5	Use tables, pictures, and graphs carefully, but not very carefully		
6	Using the right strategy, as well as the right and unreasonable reasons		
7	Demonstrates precise and thorough understanding of concepts; counts are not precise		
8	Using tables, pictures, and graphs needs to be more accurate. Using strategies that are not appropriate and reasons that are not appropriate		
9	Demonstrates precise and thorough understanding of concepts, Counts less		
10	Not using tables, pictures, or graphs. Using inappropriate strategies and inappropriate reasons		

Table 2. Performance Assessment Analytical Rubric

No	Problem Solving Aspect	Score		
		1	2	3
1	Understanding Problems			
2	Completion Planning			
3	Student Answers			

3. Result and Discussion

Result

The object of this study is the difference in students' higher-order thinking skills due to the treatment between learning approaches. The form learning approach in this study is divided into the STEAM approach based on performance assessment and the conventional learning approach. This study grouped students' higher-order thinking skills following the STEAM approach based on performance assessment and students' higher-order thinking skills following conventional learning approaches. The results of the analysis of central measures (mean, mode, median) and measures of data distribution (variance and standard deviation) on students' higher-order thinking ability scores are presented in Table 3.

Table 3. Recapitulation of Students' Higher-Order Thinking Ability Scores

		Y_1	Y_2
N	*Valid*	*41*	*41*
	Missing	*41*	*41*
Mean		*73.1220*	*61.1951*
Median		*74.0000*	*61.0000*
Mode		*74.00[a]*	*60.00*
Std.Deviation		*5.36281*	*5.24985*
Variance		*28.760*	*27.561*
Range		*22.00*	*23.00*
Minimum		*60.00*	*48.00*
Maximum		*82.00*	*71.00*
Sum		*2998.00*	*2509.00*

Information:

Y_1 = higher order thinking ability of the experimental group

Y_2 = higher order thinking ability of the control group

The normality test is carried out to ensure that the statistical test used in testing the hypothesis can be carried out. It is important because if the data is not normally distributed, the t-test, which is a parametric statistic, cannot be performed. The normality test in this study used

the Kolmogorov-Smirnov data on both groups of students' higher-order thinking skills. The normality test results are presented in Table 4.

Table 4. Data Normality Test Results

Tests of Normality

	Kolmogorov-Smirnov[a]			*Shapiro-Wilk*		
	Statistic	*df*	*Sig.*	*Statistic*	*df*	*Sig.*
Y1	*0.102*	*41*	*0.200*[*]	*0.976*	*41*	*0.528*
Y2	*0.093*	*41*	*0.200*[*]	*0.979*	*41*	*0.640*

a.LilliforsSignificanceCorrection

**.Thisisalowerboundofthetruesignificance*

Analysis of the Kolmogorov-Smirnov and Shapiro-Wilk tests shows that the sig. > 0.05 for both data groups, namely data on higher-order thinking skills for the experimental group (Y1) and the control group (Y2), as shown in the table above. It means that H0 is accepted (failed to be rejected), and both sample groups are normally distributed. The homogeneity of variance test is intended to ensure that the differences obtained from the t-test come from differences between groups, not due to differences within groups.

The analysis of the homogeneity of variance test using SPSS 16.0 for Windows obtained the result, namely the sig. > 0.05 or 0.723 > 0.05; so that H0 is accepted. It means that both groups come from populations with the same or homogeneous variance. So the data on students' higher-order thinking skills come from a homogeneous population. Based on the results of the prerequisite test, namely the normality test of data distribution and the homogeneity test of variance, it can be concluded that the data on students' higher-order thinking skills come from a population that is normally distributed and has the same or homogeneous variance. Therefore, hypothesis testing with a t-test can be done. The recapitulation of the results of data analysis using the parametric statistical t-test can be seen in Table 5.

Table 5. Hypothesis Test Results

Independent Samples Test

	Levene's test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Intervalofthe Difference	
	F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Y Equal variances assumed	0.126	0.723	10.176	80	0.0001	11.92683	1.17204	9.59440	14.25926
Equal variances not assumed			10.176	79.964	0.0001	11.92683	1.17204	9.59438	14.25928

The analysis results show that the significant t-count for the assumption of equal variance (equal variance assumed) for the two-tailed test is 0.001. So that the sig.< value of 0.05 or 0.001 <0.005. It means that H0 is rejected and H1 is accepted. There are differences in higher-order thinking skills between students who follow the STEAM approach based on performance assessment and students who follow conventional learning approaches. The results of the data analysis also showed that the group that followed the STEAM approach based on performance assessment had a high-order thinking ability score of 73.122. In contrast, the students who followed the conventional learning approach had an average higher-order thinking ability score of 61.195. Thus the average higher-order thinking ability of the student group following the STEAM approach based on performance assessment is higher than the average higher-order thinking ability of the student group following the conventional approach.

4. Discussion

The results of data analysis using the t-test showed differences in higher-order thinking skills between students who followed the STEAM approach based on performance assessment and students who followed conventional learning approaches. The STEAM approach based on performance assessment can improve students' higher-order thinking skills. It is caused by several factors, namely, as follows. First, the STEAM approach based on performance assessment improves students' understanding of learning. The STEAM approach based on performance assessment is a learning approach that can challenge students to actively solve problems by connecting their knowledge and skills (Aguilera & Ortiz-Revilla, 2021; Degeng et al., 2021; Pasani & Amelia, 2021). The STEAM approach is an applied learning approach that uses an interdisciplinary approach to provide a cohesive learning paradigm for learning various academic concepts alongside the real world (Arce et al., 2022; Nkulikiyinka et al., 2020). In addition, this approach by applying five scientific disciplines, namely science, mathematics, engineering, art, and technology, increasingly shows the advantages of the STEAM approach compared to conventional approaches (Bayles et al., 2021; Jesionkowska & Wild, 2020; Komala & Rohmalina, 2021; Mabsutsah & Yushardi, 2022). The STEAM approach is very suitable to be applied in learning during today's increasingly rapid development of the digital era. Steam is a learning model that encourages children to be more creative in solving problems and thinking symbolically and logically. STEAM (Science, Technology, Engineering, Art, and Mathematics) in the learning process is packaged by combining science, technology, engineering, mathematics, and art (Bedar & Al-Shboul, 2020; Conradty & Bogner, 2018; Estriyanto, 2020; Herranen et al., 2021; Kim & Kim, 2016). With the STEAM learning model, children are stimulated to think critically in the learning process to increase student understanding in learning. Previous research findings also reveal that the STEAM approach can improve students' understanding of learning (Jesionkowska & Wild, 2020; Zharylgassova et al., 2021). In addition, other findings also reveal that the STEAM approach makes it easier for students to understand learning, so it has an impact on increasing student learning outcomes (Rahmawati et al., 2019; Sartono et al., 2020).

Second, the STEAM approach based on performance assessment promotes an innovative learning environment. Based on this, applying approaches and assessments in the learning process plays a very important role because it is a conceptual framework in the form of a systematic learning plan. The STEAM approach is a learning model that can challenge students to actively solve problems by linking knowledge and skills as an applied learning approach

(Aguilera & Ortiz-Revilla, 2021; Bedar & Al-Shboul, 2020; Jesionkowska & Wild, 2020). Students are required to use an interdisciplinary approach to present a cohesive learning paradigm to learn various academic concepts that are juxtaposed with the real world by applying five disciplines, namely science, mathematics, engineering, art, and technology (Arce et al., 2022; Nkulikiyinka et al., 2020). Therefore, the STEM approach aims to provide students with the knowledge needed to deal with unexpected changes in the world. The STEAM learning model will foster a creative attitude in students. Students will produce a product or work according to their imagination, increasing an innovative learning atmosphere (Rahmawati et al., 2019; Sartono et al., 2020). STEAM-based learning is important to be applied in the teaching and learning process because it has several advantages, including preparing a generation ready to face the times and helping to develop innovations in life. It is also supported by previous research findings, which state that the STEAM approach can increase students' interest in the profession in the STEAM field as well as help students to build self-concepts actively, as well as increase student literacy regarding STEAM (Dwi Sari & Setiawan, 2020; Erol et al., 2022; Lindeman et al., 2014). STEAM-based learning can also be linked to the need to develop 21st-century skills for students, namely critical thinking, creativity, collaboration, and communication skills (Aguilera & Ortiz-Revilla, 2021; Degeng et al., 2021; Pasani & Amelia, 2021). In line with this, STEAM-based learning also requires students to identify a problem, create something to solve the problem, collaborate with classmates to solve problems, communicate effectively, and respond to each other's ideas. It makes learning more enjoyable.

Third, the STEAM approach based on performance assessment improves students' thinking skills. The advantages of the STEAM learning approach based on performance assessment compared to conventional learning approaches can be seen from students' average high-level thinking ability. The results of the data analysis indicate the superiority of the STEAM approach based on performance assessment compared to the conventional approach. This advantage is limited to theoretical descriptions and has been tested empirically in the field. The application of approaches and assessments in the learning process plays a very important role because they are a conceptual framework in the form of a systematic learning plan (Degeng et al., 2021; Nkulikiyinka et al., 2020). To apply STEAM learning, students are encouraged to find systematic and iterative ways to design objects, processes, and systems to meet human needs and desires (engineering). Engineering elements in STEAM can start from a problem, need, or desire with measurable criteria, which are then tested to identify constraints or limitations (Arce et al.,

2022; Bedar & Al-Shboul, 2020; Dwi Sari & Setiawan, 2020; Erol et al., 2022; Lindeman et al., 2014).

Learning using the STEAM approach focuses on communication, collaboration, finding solutions, research, and critical and creative thinking. In addition, students will be trained to focus on problem-solving, build systematic and logical thinking, and sharpen critical thinking skills (Herranen et al., 2021; Sartono et al., 2020). STEAM encourages children to think more critically to be better prepared to face the industrial revolution 4.0. Research results. Research further strengthens the advantages of the STEAM approach compared to conventional approaches, namely that STEAM can increase scientific literacy and interesting and motivating learning, help understand teaching materials, form creative attitudes, and students are increasingly aware of the importance of protecting the environment (Perignat & Katz-Buonincontro, 2019; Rahmawati et al., 2019). This approach can provide new experiences for students so that motivation and interest in learning are increased through real experiences in learning. In STEAM learning, students are invited to carry out meaningful learning to understand concepts (Hobri et al., 2021; Wulandani & Putri, 2022). Based on this research, it can be concluded that the performance assessment-based STEAM approach can improve students' higher-order thinking skills.

5. **Conclution**

The data analysis results show differences in higher-order thinking skills between students who follow the STEAM approach based on performance assessment and students who follow conventional learning approaches. The results of the data analysis also showed that the group that followed the performance assessment-based STEAM approach had better higher-order thinking skills scores. It was concluded that the STEAM approach based on performance assessment can improve students' thinking skills. Students are invited to explore through a project activity, so students are actively involved in the process. It fosters students to think critically, creatively, and analytically and improves higher-order thinking skills.

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