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Implementation of STEM Integrated Ethnoscience-based Vocational Science Learning in Fostering Students' Higher Order Thinking Skills (HOTs)

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Abstract

The low HOTs of students is caused by the lack of opportunities to think scientifically. The research objective was to analyze HOTs profiles through Analyze (C4), Evaluate (C5), and Create (C6) indicators through science learning based on integrated ethnoscience STEM (Science, Technology, Engineering, and Mathematics). The research method was a quasi-experimental one-group pretest-posttest design with a purposive sampling technique in Class X SMK Accounting 1 which consisted of 37 students. The data collection method used HOTs test questions with the concept of "Waste and Its Handling". In-depth interviews were conducted to explore ethnoscience information in Wonosobo District. Documentation of the HOTs profile of SMK students and the surrounding environment in the Dieng Wonosobo plateau area. The t-test to analysis the effectiveness of STEM integrated ethnoscience learning in increasing HOTs. The results showed the HOTs profile of vocational students on the analyze indicator (C4) was 73.3%, evaluated (C5) was 71.5%, and created (C6) was 67.8%, Based on the t-test was t_{count}: 2.08, t_{table}: 2, 00, dk: 72, α: 5%, so $t_{count} > t_{table}$, then H0 rejected and H1 accepted means that there is the effectiveness of STEM integrated ethnoscience-based science learning in increasing the HOTs of SMK students. The contribution of exploring in ethnoscience information sources through STEM literacy

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INTRODUCTION

Empowerment of Vocational High School students is a 21st-century skill that must be cultivated based on the recommendation of the Directorate of Vocational School Development, the reason is to prepare professional and productive prospective graduates (Winarno et al., 2015). The results of the investigation of SMK science learning can provide future life skills through STEM literacy (Science, Technology, Engineering, and Mathematics). The sophisticated digitalization system in the 21st century seems to erode traditions that have been rooted in society, while students' higher-order thinking skills (HOTs) are low. The low number of HOTs is triggered by some teachers perceiving HOTs as a process that is only done individually (Pascual et al., 2017; Tendrita et al., 2016). Teachers do not know the right way to increase student HOTs in the learning process in class (Laius et al., 2015).

Science learning is designed with the HOTs approach to address global problems and is able to understand science through the discovery process (McFarlane, 2013; Suciati, 2017)HOTs as the ability to generate new and appropriate ideas (Anwar et al., 2012; Diki, 2014; Tendrita et al., 2016), so that the goals of science education are achieved to adapt to different conditions, think flexibly, be creative, think critical, respectful of society and tolerant of ideas (Ogawa, 1986; Okwara & Upu, 2017). The purpose of science education is very relevant to the Regulation of the Minister of Education and Culture of the Republic of Indonesia of 2016 Number 24 concerning basic competencies in SMK Natural Science regarding core competencies in the aspect of skills.

The achievement of HOTs based on the results of the Vocational School Examinations for SMK students in Wonosobo Regency for 2018/2019 Academic Year of Science subjects showed a mean of 43.67 and a standard deviation of 15.20 with a low category. Research (Sugiyanto et al., 2018) also shows that the average HOTs of vocational students in Klaten Regency is in the low category of 13.71%. Furthermore, (Suciati et al., 2015) that students' creativity is exacerbated by the low category test results of 43.56%.

The next fact is in the results of observations about learning readiness, there are 65% of teachers in making modules on the material that is taught not HOTs oriented, while vocational students are required to have high-level thinking skills in the 21st century. Science learning still relies on how to understand concepts and has not become a means. to empower students' HOTs (A. Khoiri, Sunarno, Sajidan, & Sukarmin, 2019; A. Khoiri & Sunarno, 2019; Sumarta, 2017). The learning approach used to develop HOTs is too difficult for students who have limited knowledge and HOTs, besides that they can also appreciate their own culture through an integrated STEM ethnoscience-based learning approach.

Ethnoscience-based learning improves science process skills and student appreciation (Atmojo, 2012), learning achievement (Okwara & Upu, 2017) and the ability to use scientific knowledge (Sudarmin et al., 2014). Ethnoscience-based learning, individuals increasingly master the concept of science in culture, because students learn directly in the environment (Becker & Park, 2011) so that the form of appreciation in the form of curiosity and attention to the traditions and culture of society increases (Okwara & Upu, 2017). Ethnoscience learning is proven to be able to increase the creative part of students' HOTs through environmental learning resources (A. Khoiri, 2016; A Khoiri & Haryanto, 2018; A. Khoiri, 2018).

The next problem regarding the implementation of education based on local excellence or cultural traditions of the local community from 15 (fifteen) SMK in Wonosobo Regency shows that 69% of schools have not implemented it. This is what encourages vocational students to not know the local potential and cultural traditions of their own region, I should have local potential as an effort to build student character. Although overall teachers already know the local potential in Wonosobo, it is proven that only 38% are able to use it to solve science problems. Ideally, HOTs is the capacity to go beyond the information provided, to take a critical attitude, evaluate, have metacognitive awareness and problem-solving capacity. Based on the existing problems, the importance of analyzing student HOTs through Vocational Science learning based on STEM integrated ethnoscience to prepare prospective professional graduates who can compete globally without leaving culture as a national character.

METHODS

This type of research is a quasi experimental one group pretest postest design. The study population was all students of class X SMK Takhassus Alquran Wonosobo, totaling 543 students. The purposive sampling technique was selected by Class X Accounting 1, totaling 37 students. The data collection method uses HOTs test questions in the form of a description of the concept of "Waste and Its Treatment". Documentation of environmental profiles in the Dieng Plateau area to assess waste. The analysis technique used the t-test to determine the effectiveness of STEM integrated ethnoscience learning in increasing student HOTs. The research approach uses the thought process dimension at the Analyze (C4), Evaluate (C5) and Create (C6) level (Anderson et al., 2001) is presented in Table 1.

Table 1. Dimensions of HOTs Thinking Process

Level	Dimensi	Operasional	Category
C6	Create	Create your own ideas or ideas	HOTs
C5	Evaluate	Make up your own mind	HOTs
C4	Analyze	Specifies aspects or elements.	HOTs
C3	Apply	Use different domain information	MOTs
C2	Understand	Explain an idea or concept.	MOTs
C1	Knowing	Recalling.	LOTs

The entire research process of implementing Vocational Science learning based on STEM integrated ethnoscience in growing student HOTs is presented in Figure 1.

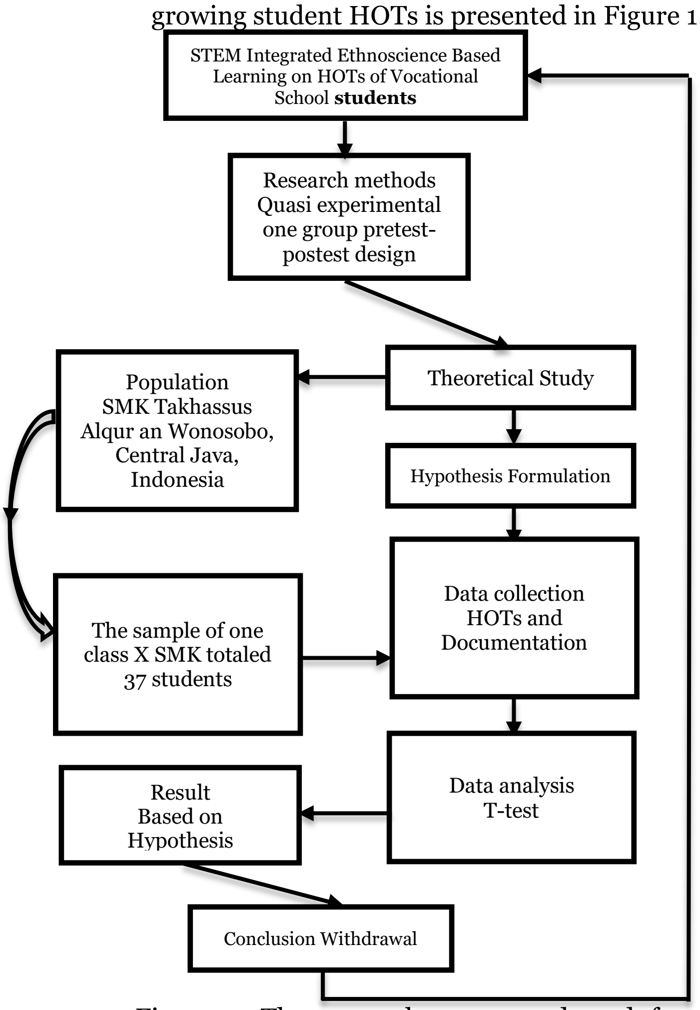

Figure 1. The research process adapted from (Ahmad Khoiri & Sunarno, 2019)

RESULT AND DISCUSSION

RESULT

The results of preliminary observations about the student's HOTs profile based on the test scores of the material "Waste and Its Handling", while the illustration of HOTs questions is presented in Figure 2.

Figure 2. Illustration of Integrated HOTs Question STEM Ethnoscience material "Waste and Handling"

Based on Figure 2, the answers of respondents, totaling 37 students, are presented in Table 2, which are the results of the pre-test and post-test of science learning.

Table 2. Data for pre-test and post-test HOTs of SMK students

Data	Pre test	Pos test
The highest	78	88
Lowest	50	56
Average	64,7	71,2
Standard Deviation	0,22	0,23
Variance	0,44	0,49

Furthermore, Table 3 is analyzed based on the HOTs profile of the students using post-test scores after the implementation of STEM integrated ethnoscience-based Vocational Science learning.

Table 3. HOTs Profile Data of SMK Students

Data Range	Frequency
51-60	4
61-70	15
71-80	14
81-90	4
91-100	0
Rata-rata	71,2

Based on Table 3, it shows that the average HOTs is 71.2% with learning completeness of 51%. The HOTs profile on each indicator Analyzes (C4), Evaluates (C5) and Creates (C6) is presented Table 4 pre-test data and Table 5 post-test science learning based on STEM integrated ethnoscience.

Table 4. HOTs data for each indicator (pre-test)

Criteria	Analyze (C4)				Evaluate (C5)			Create (C6)		
Question Items	1	2	3	4	5	6	7	8	9	10
Score	258	286	198	226	234	201	288	243	237	224
Ideal Score	370	370	370	370	370	370	370	370	370	370
Percentage	69,7	77,3	53,5	61,1	63,2	54,3	77,8	65,7	64,1	60,5

Table 5. HOTs data for each indicator (post test)

Criteria	Analyze (C4)				Evaluate (C5)			Create (C6)		
Question Items	1	2	3	4	5	6	7	8	9	10
Score	275	308	256	247	258	237	299	259	266	228
Ideal Score	370	370	370	370	370	370	370	370	370	370
Percentage	74,3	83,2	69,2	66,8	69,7	64,1	80,8	70,0	71,9	[illegible]

Based on Table 4 and Table 5 shows the average percentage to determine the HOTs profile for each indicator C4, C5 and C6 in Figure 3.

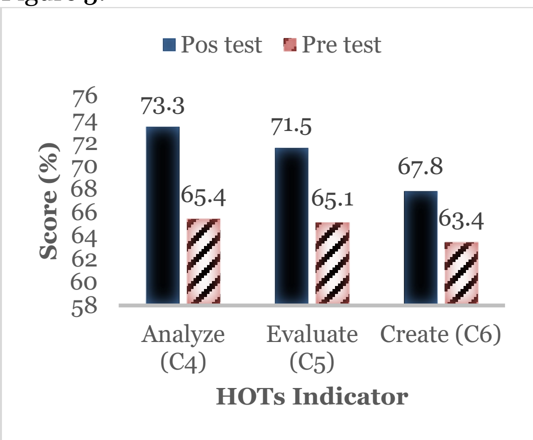

Figure 3. HOTs Profile Data of SMK students

DISCUSSION

1. STEM integrated ethnoscience-based science learning

Figure 3 shows the students' answers before and after the completed science lesson as an indicator of the HOTs profile. The HOTs problem is presented in the form of ethnoscience learning resources that emphasize the thought of reconstructing original science into scientific science in giving students the opportunity to gain scientific knowledge (Sumarni et al., 2016). Students can explore the reconstruction process through the knowledge that develops in the community in the form of waste from the Carica and Opak cassava industries. Learning IPA SMK based on STEM integrated ethnoscience, students take advantage of technology to find learning sources and media. The engineering aspect in utilizing the tools used in the utilization of carica and cassava peel waste, then the mathematical aspect in calculating mathematical formulas. The illustration of the concept implemented in science learning is presented in Figure 4.

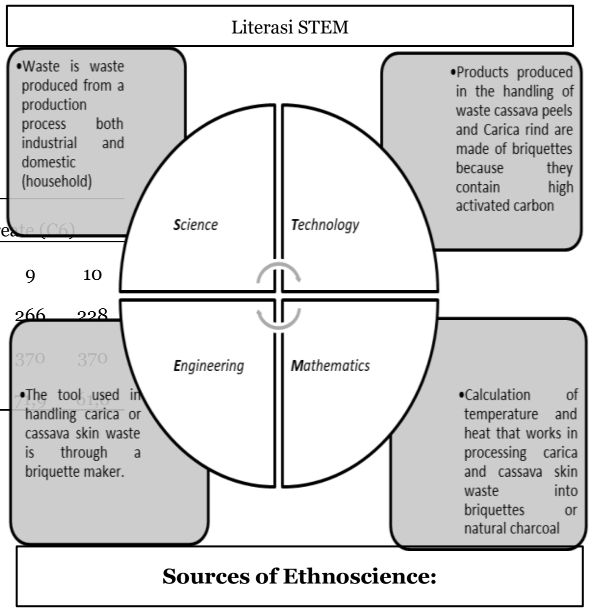

Figure 4. Implementation of Vocational School applied science learning based on STEM integrated ethnoscience.

Figure 4 shows the activities carried out by students in developing higher order thinking skills. Students are given the opportunity to analyze, evaluate and create on the concept of waste. One of them is the carica industrial waste as the culture of the Wonosobo community in utilizing carica fruit as sweets. Industrial discarded leather becomes waste, if left untreated it will have a negative impact on the environment, so it is necessary to use the waste into a product that can be utilized as shown in Figure 5.

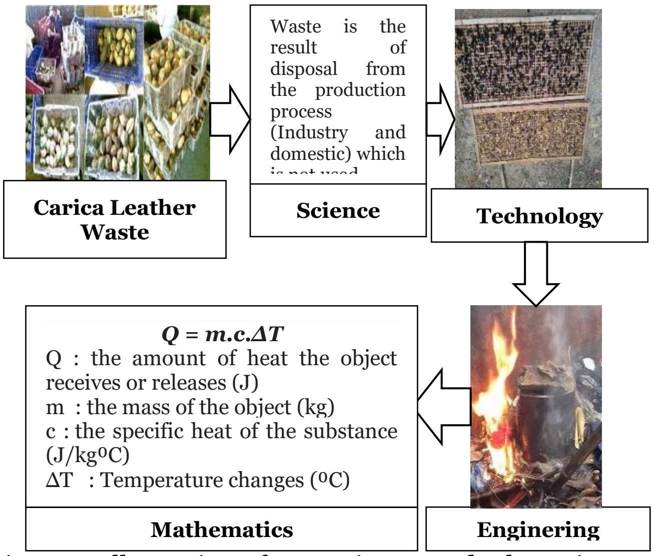

Figure 5. Illustration of STEM integrated ethnoscience-based waste concept.

Scientifically Figure 5 shows the waste of Carica Leather is a waste product from the production of Carica drinks in the Wonosobo district. Carica production comes from endemic Carica plants which only grow in certain areas. Furthermore, the cassava peel produced by some of the people of Wonosobo, Central Java is one of the solid waste produced in the manufacture of cassava chips processed by home industries. This waste contains a fairly high carbon element of 59.31%. This is the basis that cassava peels can be used as raw material for making activated carbon. Such scientific concepts can provide students with opportunities to think at higher levels. Ethnoscience-oriented learning integrated STEM students will more easily understand scientific concepts and meaningful learning.

2. HOTs profile of SMK students

HOTs has emphasized the process of thinking through analysis (C4), evaluation (C5), and creativity (C6). HOTs can train high-level thinking skills of vocational students who rely on the ability to analyze, evaluate and create all aspects and problems, not just repeating material or knowing existing facts to build concepts through collaboration and composition of what is known to stimulate the ability to think into levels or higher levels. This is confirmed by (Rondan-Cataluña et al., 2015) showing that creative activity can increase HOTs.

HOTs places more emphasis on thinking skills that combine critical thinking and creative thinking. It is strengthened by research (Ahmad Khoiri, 2018) that critical thinking is thinking rationally about something. Rational by the facts build a new paradigm that is more creative and can create a concept into something or something new (Anderson et al., 2001) Learning resources that contain material content as well as practice questions or student activity sheets oriented to HOTs, presenting students' problems, emphasizing the habit of thinking, finding and simulating work results. The habit of thinking is the application of past knowledge to new situations through meaning, thinking, and communication by organizing vocational, rational, and academic learning so that intellectual behavior patterns will be formed.

Vocational science learning based on STEM integrated ethnoscience can stimulate students in understanding facts, grouping, drawing conclusions, connecting them with other facts and concepts, making generalizations, and applying them by looking for new solutions (Cintang, 2016). The HOTs profile of SMK students based on Figure 3 shows that the C4 score has a higher value when compared to the C5 and C6 indicators, but in detail, each indicator is explained based on the response of the students' answers

Analyzing (C4)

Analyzing (C4) obtained the highest score of 73.3% (Figure 3) in the moderate category. Indicator analysis (C4) in the activity of comparing, examining, criticizing, testing a PT Geodipa Energi Dieng smoke waste problem which is used as a Power Plant Center. The ability to describe concepts in detail is the main factor in increasing higher-order thinking skills that can be pursued through problem-solving, creative thinking, critical thinking, and decision making on how to handle the waste. Illustrated based on students' answers in analyzing presented Figure 6 about "Question: Describe 3 Impacts of industrial waste on Dieng Geodipa Energy on health and the environment!" and student answers.

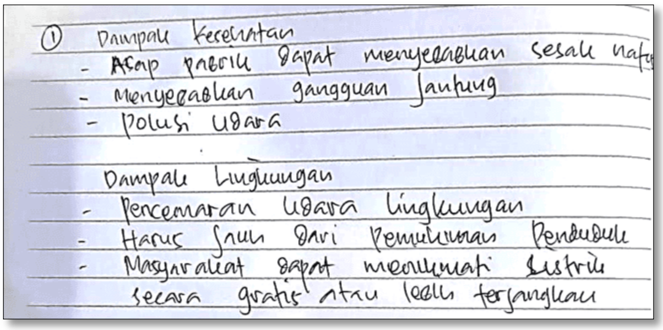

Figure 6. Answers to Analyze (C4) Students on the impact of Waste.

The next question is "the question: Describe the waste of the home industry for household cassava opaque which is easily decomposed by nature, analyze why?" presented in Figure 7 along with student answers.

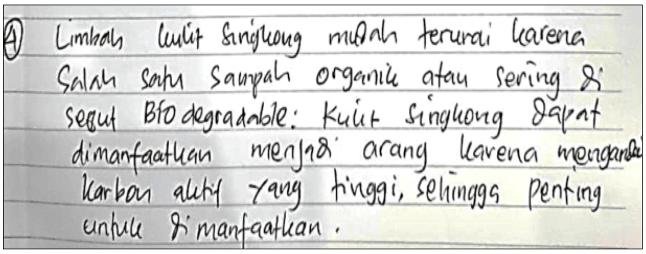

Figure 7. Answers to Analyze (C4) Students on waste utilization.

Figures 6 and 7 show that analyzing student activities are required to be able to identify, gather information, choose ethnoscience sources that can be accounted for by utilizing STEM literacy as a learning tool so that students will contribute to the study of waste and its handling with a scientific approach.

Evaluating (C5)

Evaluating (C5) obtains 71.5% (Figure 3) medium category, activities in managing decisions and conclusions based on standards that have been set through assessment criteria, assignments based on learning objectives to be achieved. Two aspects that must be considered in evaluating activities are examining and criticizing. The results of students' ability to evaluate showed difficulties in making decisions, especially those related to interpreting the concept of material in everyday life. This is because students are not accustomed to thinking about how to evaluate learning material and its practical benefits. Based on the illustration of Figure 8 "Question: Compare and Describe what components are in the picture!" along with answers to evaluate students.


Tabel 1. Perbandingan Limbah Industri yg berbeda

Sumber	disebabkan oleh	Dampak Kesehatan	Dampak Lingkungan
- Limbah Industri Carica	Kulit buah Carica tidak dimanfaatkan	- Menjadi sarang nyamuk - Menyebabkan bau tidak sedap	- Pencemaran Lingkungan - Unsur tanah menjadi tidak subur
- Limbah Industri Opak Singkong	Kulit Singkong tidak di manfaatkan	- Udara di sekitarnya menjadi bau tidak sedap	- Tidak mudah terurai dengan cepat

Figure 8. Answers to Evaluate (C5) Students on a comparison of different waste sources

Figure 8, the activity evaluates students with the ability to compare the impact of different waste sources, by looking for as many events that will occur on the environment and health as well as scientific explanations. Examining the impact on health and the environment further argues for criticism of the waste.

Creating (C6)

Creating (C6) gets 67.8% (Figure 3) in a sufficient category. Creating activities is a cognitive process that involves the ability to realize new concepts or products, emphasizing creative thinking in synthesizing information into a more comprehensive and complex form. Constraints faced by students of SMK Takhassus Al Qur'an in creating ideas into new products in formulating ideas, making works are not yet familiar, so students need a stimulus to dig up as much information as possible. The illustration in Figure 9 "Question: What is your solution in overcoming industrial waste at PT Geodipa Energi Dieng" along with answers to create. students.

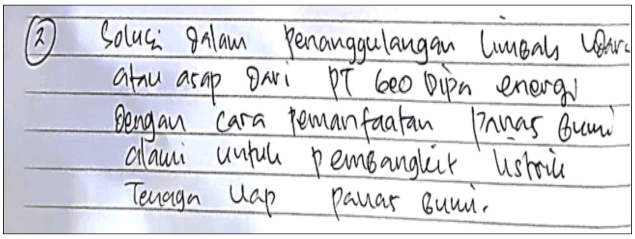
(2) Solusi dalam penanggulangan limbah udara atau asap dari PT Geo Dipa energi dengan cara pemanfaatan panas bumi alami untuk pembangkit listrik Tenaga Uap panas bumi.

Figure 9. Answers to Creating (C6) Students on Waste Utilization Solutions.

Figure 9 shows the weak ability to create in providing solutions for waste management. The difficulty of creating a part of contributing ideas, new or existing thinking is developed and modified into new ideas by providing different solutions for each student depending on the understanding and extracting information that uses technology to be the main problem in indicator C6. Even so, the creative indicator (C6) needs to be improved again in the next research, considering that the habit of thinking and creating something based on understanding the ideas of students is not enough in a short time. Based on Figures 6, 7, 8, and 9, although not fully able to improve significantly, learning activities have shown that there are student thinking activities, habits that are carried out continuously will be able to foster students' higher-order thinking skills.

Learning with cultures and traditions around students' lives will be easier for students to understand than abstract concepts. Ethnoscience is presented in community activities that are important to be studied to maintain a culture in the modernization era. Students become more aware of the culture and traditions of society, students feel part of people's lives so that students will care more about their own culture. This is confirmed by research (Parmin & Fibriana, 2019) showing ethnoscience maintains student awareness of culture and its potential and fosters learning independence.

3. The effectiveness of STEM integrated ethnoscience-based science learning in empowering the HOTs of vocational students

Based on the t test to determine whether the effectiveness of STEM integrated ethnoscience-based science learning in growing student HOTs is presented in Table 6 and Table 7.

Table 6. t-test results for each student's HOTs indicator

HOTs	Dk	t-test		sig	Criteria
		t_{hit}	t_{tab}		
C4	72	4,25	2.0	5%	H_1 accepted
C5	72	3.13	2.0	5%	H_1 accepted
C6	72	2,24	2.0	5%	H_1 accepted

Table 7. Computation Results of t-test students' HOTs (total)

Computation	Value	Decision
x_1	64,73	Criteria:
x_2	71,16	T_{count}: 2,08
s_1^2	0,04	t_{table}: 2,00
s_2^2	0,04	dk: 72
s_1	0,20	α: 5%
s_2	0,20	$t_{count} > t_{table}$
n_1	37	H_0: rejected
n_2	37	H_1: accepted
r	0,76	

Based on Table 6 and Table 7, it shows t_{count} consulted with t_{table} at dk = (n1 + n2 -2) = (37 + 37-2 = 72) of 2.00 at the 5% significance level, then t_{count} is greater than t_{table}, if 4, 25> 2.00; 3.13> 2.00; 2.24> 2.00, then H1 is accepted, meaning that there are differences in HOTs learning outcomes before and after the implementation of STEM integrated ethnoscience-based science learning. So that learning is effective in empowering the HOTs of vocational students. The characteristics of the ethnoscience approach are strategies for creating learning environments and designing learning experiences that integrate culture as part of the science learning process (Arlianovita et al., 2015; Fitriani, 2016; Parmin et al., 2015; Sudarmin et al., 2014). Culture is the result of the creation of human tastes and initiatives that develop as genuine knowledge (indigenous science) which is transformed into scientific science (Parmin & Fibriana, 2019; Sudarmin et al., 2014). Several terms can be used to refer to ethnoscience as indigenous knowledge, namely traditional ecological knowledge, traditional knowledge, and indigenous science, local culture, local wisdom (Local Wisdom or Local Genius) (Sumarni et al., 2016).

HOTs equip students to maximize meta-cognition thinking in analyzing activities. Designing and formulating in detail the concept of waste and its handling, by knowing the impact on health and the environment, furthermore, waste utilization solutions with STEM literacy. Student activity sheets are trained to find the concept of waste through the HOTs indicator. HOTs are indeed very difficult to identify in a short time because they are not immediate, but can be identified through a series of activities that orient HOTs themselves. The activity in question is a habitual activity of higher-order thinking through cognitive dimensions when evaluating, analyzing, and creating continuously. Based on the preliminary analysis on the implementation of STEM integrated ethnoscience learning, there is a significant difference in HOTs between the experimental and control classes, which means that the applied learning is effective in empowering the HOTs of SMK students.

CONCLUSION

Science learning based on STEM integrated ethnoscience can provide scientific thinking opportunities to explore ethnoscience information that develops in the community by utilizing STEM literacy. Learning success through the HOTs profile of vocational students on analyzing indicators (C4) was 73.3%, evaluating (C5) was 71.5%, and creating (C6) was 67.8%, then based on the t-test obtained t_{count}: 2.08, t_{table}: 2.00 with dk: 72 and a significance level (ɑ: 5%). The criteria for fulfilling $t_{count} > t_{table}$, then H0 is rejected and H1 is accepted, meaning that there is the effectiveness of STEM integrated ethnoscience-based science learning in increasing the HOTs of vocational students. The research recommendation is that a teacher and students prepare to learn resources and media through ethnoscience that are relevant to the 2013 curriculum, given the broad coverage of issues in society.

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