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META-ANALYSIS: THE EFFECT OF THE SCIENCE, TECHNOLOGY, AND SOCIETY LEARNING MODEL ON STUDENTS HIGH ORDER THINKING SKILLS

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ABSTRACT

This study aims to analyze the effect of the science, technology, and society (STS) learning model on students' higher-order thinking skills (HOTS) in science subjects. This influence is viewed from several aspects, namely aspects of higher-order thinking skills, education level, and dimensions of science studies. This influence is seen from the effect size (ES) in each article. This research uses the meta-analysis method of 20 (twenty) scientific articles from journals. The results of this study indicate that the STS learning model has a good effect on students' higher-order thinking skills (HOTS) in science learning. Aspects of high-order thinking skills critical thinking have the highest average effect size (ES), namely 1,84. Students at the high school level experienced higher order thinking skills development which was better than students at the junior and elementary school levels with an average ES of 1,77. The dimensions of the Biology Science study show a better effect if it is taught with the community technology science (STS) model with an average effect size (ES) of 1,70.

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INTRODUCTION

Education is a sector that has a big responsibility in shaping Indonesian people to be able to face various complex problems that arise as an implication of advances in science and technology. Various innovative efforts have been made by the government, starting from curriculum changes, improving the learning process to updating the learning evaluation system. However, it seems that it hasn't described a significant impact. This can be seen from the PISA (Program for International Student Assessment) in 2018 which placed Indonesia in the 74th rank of 79 countries and the 2007 TIMSS (Trend International Mathematics Science Study) results which placed Indonesia in 36th out of 49 countries.

Indonesia continues to improve the national education system. It is hoped that a good education system will gradually be able to answer the challenges of the progress of the times. Today, the learning process faced by students in schools does not only focus on understanding concepts but is more stressed on mastering higher-order thinking skills (HOTS) so that students are accustomed to and able to face various complex problems that exist in front of them as the impact of globalization to create a smart and competitive personality. Sadia (2011) states that a competent person is a person who is superior and longs for excellence, has high motivation, is hardworking, has a global mindset, learns throughout life, and is ready to become an agent of change. To make this happen, it is necessary to master higher-order thinking skills.

HOTS is the domain of student thinking at a higher cognitive level developed from various cognitive concepts and methods and learning taxonomies such as problem-solving methods, bloom taxonomy, and learning, teaching, and assessment taxonomies (Saputra, 2016). Various skills are categorized as HOTS, including critical thinking, creative thinking, problem-solving. HOTS includes problem-solving skills and argumentation skills. According to Schafersman (1991), higher-order thinking skills or HOTS are very vital skills to be mastered in the era of modern education.

According to Johnson (2002), the ability to think critically can be used as a means of solving problems, making the right decisions based on careful effort from various points of view. Sadia (2008) revealed that the specific purpose of learning critical thinking in science education and other disciplines is to improve students' thinking skills and at the same time prepare them to be successful in life.

Problem-solving skills are a person's ability to take advantage of his or her thinking process to solve problems through gathering facts, analyzing information, arranging various alternative solutions, and choosing the most effective problem solving (Yamin, 2008). HOTS includes the ability to solve many problems related to reflective, critical, and analytical thinking so that it is believed to be able to help students make correct, careful, systematic, logical decisions and consider various views. Therefore, this skill is required to be mastered by students in learning including science learning.

To form and develop high-level thinking skills in students must be following the strategy or learning model used. The Community Science Technology (STS) learning model is seen to be one of the innovative learning model solutions that can be used in learning including science learning. Jariyah (2017) states that the STS model combined with inquiry can improve students' critical thinking in science material. In line with that, Kemil et al (2018) found that the use of the STS model has a good effect on improving students' critical thinking skills.

Lamsihar et al (2019) stated that the application of the STS model in science learning can improve students' critical thinking skills because STS provides opportunities for students to play an active role in constructing their knowledge. According to Rustum (1983), STS learning in science is a strategy that can combine science, technology, and society. Social and technological problems in society are the main characteristics of this learning model. Through the STS model, students will learn science in the context of their real experiences, which are related to the application of science and technology.

Through STS learning, it is expected to be able to encourage students to see science as their world so that they can provide experiences to students like what scientists experience. Technology in STS is expected to be able to link science with society. So that STS as a learning model can be effectively used in improving students' higher order thinking skills at various levels of education.

METHOD

This study uses a type of meta-analysis. Meta-analysis research is a study of several research results in similar problems. This study is a secondary integrative analysis by applying statistical procedures to the results of testing the research hypothesis. Glass et al (1981) stated that secondary analysis is a re-analysis of data to

answer research questions with better statistical techniques.

The data collection technique is done by searching for journals and scientific articles related to the STS model and its effect on HOTS in science learning (Physics, Biological Chemistry) which includes critical thinking, creativity, problem-solving, and scientific literacy. Articles analyzed in this study, there are 20 articles published by national journals. The articles analyzed are articles published from 2013 to 2020.

This study uses secondary data because the data is obtained from the results of research that has been conducted by previous researchers. Data were collected using documentation techniques. The data tabulation can be followed by the following steps: (1) identify the research variables and then enter them into the appropriate variable column; (2) identification of the mean and standard deviation of the experimental and control group data for each research subject; 3) If the standard deviation is not known, the formula for the value of t can be used; (4) If the standard deviation is known, the calculation of the effect size (ES) can use the Glass formula (Glass, 1981). The criteria for calculating the effect size (ES) are shown in Table 1. The formula for calculating the effect size (ES) is:

$$SE = \frac{\overline{x}_{postest} - \overline{x}_{pretest}}{SD_{pretest}}$$

Atau

$$SE = t\sqrt{\frac{1}{x_E} - \frac{1}{x_C}}$$

Keterangan :

SE = size effect
$X_{postest}$ = post-test mean
$X_{pretest}$ = pre-test mean
$SD_{pretest}$ = Standard deviation
X_E = mean of experiment group
X_C = mean of control group
t = t value
n = number of sample

Table 1. *Effect size* category(ES)

No	ES	Category
1	ES ≤ 0,15	Can be ignored
2	0,15 < ES ≤ 0,40	Low
3	0,40 < ES ≤ 0,75	Moderate
4	0,75 < ES ≤ 1,10	High
5	1,10 < ES ≤ 1,45	Very high

RESULTS AND DISCUSSION

The Influence of the STS Learning Model in terms of HOTS Aspects

From a number of documented articles, the first part analyzed in the results of this study is the influence of the Community Science Technology (STS) learning model in terms of HOTS aspects, in detail can be seen in table 2.

Table 2. Average Effect Size Effect of STS in terms of HOTS Aspects

No	*HOTS aspects*	Article Code	ES	Category
1	Creative thinking	A1 (1,68) A2 (1,61) A3 (1,10) A4 (0,23) A5 (1,28)	1,18	Very high
2	Critical thinking	A6 (0,56) A7 (2,30) A8 (1,86) A9 (2,60) A10 (1,13) A11 (2,10) A12 (1,64) A13 (2.12) A14 (1,17) A15 (2,65) A16 (2,22) A17 (2,13) A18 (1,45)	1,84	Very high
3	Problem solving	A19 (0,86) A20 (1,21)	1,03	High

In table 2 it can be seen that the application of the STS model in learning has an influence on higher-order thinking skills (HOTS). The strongest influence was in the critical thinking aspect with an average of ES 1.84 in the high category, the influence on creative thinking was found on average ES 1.18 in the high category, while in the aspect of problem-solving ability it was found that the average ES 1.03 with high category.

Based on the analysis carried out as in table 2, it can be explained that the STS learning model has a very strong effect on HOTS in science learning. The HOTS aspect of critical thinking has the strongest influence compared to creative thinking and problem solving with an average ES of 1.84 in the very high category. In general, the application of the model

STS learning has a positive impact on student HOTS in science learning. This shows that the STS learning model is effectively used in science learning to develop and improve student HOTS. The results of this study are in line with Jamilah et al (2018) who found that students who studied

with the STS model showed better critical thinking skills than students who learned with direct learning.

Astuti et al (2019) found that the application of the STS model can improve students' critical thinking. In line with that, related to the increase in higher-order thinking after STS learning was used, it was also found by Makhvudah et al (2020) that there was an increase in students' creative thinking. The same thing was also found by Maemunah and Maryuningsih (2013) that the application of the STS model can increase student creativity.

Novitasari et al (2020) found that the STS learning model affects students' critical thinking skills in science material. In line with that, Agustini et al (2018) stated that the STS learning model can be used as an alternative model in learning so that it is able to develop students' problem-solving abilities. Nurhayati (2011) shows that the SETS (Science Environment Technology Society) or STS model has a great influence on students' critical thinking skills. Research conducted by Sadia (2008) also shows that differences in treatment influence students' critical thinking skills and knowledge in the experimental class. In line with that, Budiningsih (2015) states that science teaching materials are literacy-oriented and STS helps students think critically.

The magnitude of the influence of STS on students 'critical thinking skills is because STS can integrate into students' abilities well in analyzing problems so that it can come up with logical reasoning ideas by making reasonable considerations. This is in line with Riswandi's (2013) opinion that critical thinking skills use the basis of thinking to analyze problems and generate insights into each interpretation to develop logical reasoning patterns and make the right decisions.

Marliani et al (2018) stated that the learning model of Science, Technology, Society, Environment has a positive effect on students' critical thinking. In line with that, Dwipayana (2017) found that STS affects problem-solving because it is trained to think critically. In line with that, Purnamasari et al (2017) stated that the application of the STS learning model has a positive effect on the development of students' critical thinking.

Burris & Garton (2007) show that differences in treatment influence students' critical thinking skills and knowledge. This is also reinforced by research conducted by Riani et al (2018) which shows that there are differences in critical thinking skills that are better between groups of students who use STS compared to direct learning.

In addition to critical thinking, creative thinking and problem solving also have a positive impact from the implementation of STS in learning. Smarabawa et al (2013) stated that STS learning improves students' creative thinking. The same thing was also found by Purwaningtyas et al (2014) that STS learning has a positive impact on student creativity.

The Influence of the STS Learning Model in terms of Education Level

Based on the analysis of the articles collected, it was found that the effect of the STS learning model on students' HOTS is based on the average ES in terms of education level. This data can be seen in table 3.

Table 3. Average Effect Size Effect of STS in terms of education level

No	Education Level	Article code	ES mean	Category
1	Elementary	A4, A5, A14	0,89	High
2	Junior high school	A3, A7, A12, A13, A16, A19, A20	1,63	Veri high
3	Senior high school	A1, A2, A6, A8, A9, A10, A11, A15, A17, A18	1,77	Very high

In Table 3, it can be seen that the highest influence of the STS learning model on HOTS is found in high school students with an average ES of 1.77 in the very high category. At junior level also shows a very high effect with an average ES of 1.63, but seen from the quantity, the average at the high school level is higher than at the junior high school level. Meanwhile, at the SD level, it was found that the effect was in the high category with an average ES of 0.89.

Table 3 shows that the STS model has a different effect on elementary, junior high, and high school students. However, in general, SS has a good impact at each level of education, this can be seen from the average ES. High school students get a better impact after learning using the STS model. This is due to the maturity of thinking and the level of independent learning.

The high average effect size (ES) at the high school level compared to elementary and junior high levels is an implication of children's cognitive development. Suralaga (2010) explains that psychologically, students at the junior and senior high school levels are at the formal operational stage according to Piaget's theory of development, namely at the age of 11 years to adulthood. At this stage the child is able to think abstractly and logically, the more mature with existing experiences, this ability will further develop (Budiningsih, 2015). This is what causes students' higher-order thinking skills to get better with age and education level.

At the elementary level, the application of the STS model has also had a good impact, although in terms of quantity it is indicated that the application of STS is more suitable for junior and senior high school levels. Utami et al (2019) stated that the STS model improves the critical thinking skills of elementary school students. In line with that, Rachmawati and Rohaeti (2018) found that the STS model can improve students' critical thinking.

The Influence of the STS Learning Model in terms of the Dimensions of Science

The effect of the STS learning model on HOTS in terms of the dimensions of scientific studies can be seen in table 4. In table 4, it can be seen that the STS learning model has a very strong influence on every dimension of science studies both in biology, physics, chemistry, and integrated science. The strongest influence was found in the biological sciences with an average ES of 1.70 then followed by the dimensions of chemistry, integrated science, and physics with ES 1.69 each; 1.67; 1.43.

The application of the STS model to the four dimensions of science studies, namely biology, physics, chemistry, and integrated science, has a different impact specifically, but generally has a positive impact on the development of students' thinking in exploring the four dimensions of science studies. Students who study Biology material show a better average impact of the model. This is due to the biological characteristics that are more complex than other dimensions of science studies. Although in general, the characteristics of scientific studies including science are the same.

Table 4. Average Effect Size Effect of STS in terms of the dimensions of Science

No	Dimension of science	Article code	ES mean	Category
1	Biology	A1, A2, A3, A6. A7, A8. A9, A10	1,70	Very high
2	Physics	A16, A19, A20	1,43	Very high
3	Chemistry	A17, A18	1,69	Very high
4	Integrate sciences	A4, A5, A11, A12, A13, A14, A15	1,67	Very high

CONCLUSION

Based on the analysis of the articles conducted, it can be concluded that the Science Technology Society (STS) learning model has a good influence on students' higher-order thinking skills (HOTS) in science learning. Students at the high school level experienced better HOTS development compared to SMP and SD levels. The dimensions of the Biological Science study show a better effect if taught with the STS model.

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