The impact of the science technology society (STS) approach on critical thinking ability and student learning outcomes

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Abstract. The research objective was to determine the application of the science and technology society (STS) approach in improving critical thinking ability (CTA) and student learning outcomes (LO) at High School Darul Ihsan Aceh Besar. This study used a pre-experimental method with a One Group Pre-test Post-test design. The instrument used in this study was a measurement test of critical thinking ability and learning outcomes. The results of descriptive data analysis show that the application of the Science-Technology-Society approach can improve critical thinking ability and can improve student-learning outcomes in the topic of harmonic oscillation. Besides, it also shows that the post-test score reaches the average value of 88.3 and the average N-gain reaches 75 points that is included in the high criteria of gains. The results of study shows that the science and technology approach to society can improve critical thinking ability and better learning outcomes, especially in the topic of harmonic oscillation.

1. Introduction
Learning science is one that emphasizes the development of scientific knowledge and attitudes. Science has an important role to know and formulate natural phenomena in the form of knowledge, facts, principles, concepts, discoveries, curiosity, openness and honesty [1]. The rapid development of science in the 21st century requires humans to work hard to adapt to all aspects of life [2,3]. In the world of education, one of the efforts that can improve and develop the science learning process in the modern era or 21st century is through the learning approach [4]. The approach that is often used in conveying scientific concepts is to combine the experience of the science process and the understanding of science products with direct experience [5]. One learning approach that can develop science and technology ability in the learning environment of students is the Science and Technology Society (STS) approach. This approach can combine science in the community environment with the increasingly rapid development of technology [6,7]. Several studies that have been conducted related to STS show that STS can optimize the quality of education [8], emphasize learning science concepts in the context of real-life experiences and their applications [9], and are able to motivate students to learn actively and be responsive to issues that are exist in real life [10]. Besides, STS can help students to develop cognitive,
affective, and psychomotor abilities from within students [11], it can improve students' understanding of science [12], can be used to train students' critical thinking ability [13] and can also improve students' critical thinking ability [14].

The ability to think critically is one aspect of higher order thinking ability (HOTS) and is a basic skill needed by students to solve problems in everyday life [15, 24]. Increasing critical thinking ability is not only with the STS approach, but there are also several approaches, models, methods or techniques that have been used to improve critical thinking ability, including using the Problem Based Instruction method [16], Clicker assisted teaching [17], Student-based Worksheets. Multirepresentative [18], Minnesota strategic problem solving model [19], media tracker [20], cooperative learning type TAI [21], PBL with scientific approach [22, 23], cooperative learning type Jigsaw [24] and STEM-based ISLE [25]. Based on the results of observations and interviews at High School Darul Ihsan Aceh Besar, it shows that STS and student learning outcomes are still very low. These findings are supported by the average results of the National Exam scores for the last four years in physics, namely 50.3, 38.89, 35.31 and 60.42 [26]. One of the reasons for the low scores of the National Examination is that students are less motivated, less interested, often conventional methods of teaching physics concepts and are related to the content of physics subjects with technology and real examples in students' daily lives. Based on the results of previous research studies and the conditions of the school being reviewed, the use of the Science and Technology Society (STS) approach in teaching physics is an alternative solution. Therefore, the purpose of this study is to (i) determine the increase in students' critical thinking ability and (ii) determine the increase in student learning outcomes in physics subjects.

2. Research Method

2.1. Research approach
The research approach used is a quantitative approach, the research method chosen was pre-experimental and the research design used was a systematic study to test causal hypotheses. The design used in this study was the One Group Pre-test Post-test [27].

2.2. Population and sample
The population in this study were all students of class X in 2020 consisting of 7 classes or as many as 210 students. While the sample selection of 29 students from class X-1 was carried out using purposive sampling technique, meaning that the research sample was the class X student who had the lowest minimum completeness criteria (MCC).

2.3. Learning media
To facilitate the implementation of teaching using the Science and Technology Society (STS) approach, several learning tools were developed, including (i) a physics syllabus, (ii) a learning Implementation plan (LIP), (iii) student worksheets (SW), and (iv) learning evaluation instruments. Before being used, all the learning tools are validated by content experts and media experts.

2.4. Research implementation (treatment)
The core activity of research activities is the implementation of learning using the Science and Technology Society (STS) approach. The target of implementing learning activities with the STS approach refers to the domains suggested by Yager [31], namely the domains of concepts, processes, applications, creativity and attitudes. The steps for implementing learning with the STS approach in full have been formulated in the Learning Implementation Plan including (i) phase 1 invitation, perception and motivation, (ii) phase 2 exploration, (iii) phase 3 explanation and solution, and (iv) phase 4 Follow-up. The implementation of these steps used the interview, question-and-answer and discussion method. The preliminary and final tests for critical thinking ability (CTA) and student learning outcomes (LO) are carried out before the implementation of learning and after the implementation of learning.
2.5. Collecting of data
In accordance with the research objectives, the data collection instruments used were the critical thinking ability test (CTA) and the student-learning outcome test (LO). The CTA test instrument was adopted from Leandro [28], Tiruneh [29], and Facione [30] with the indicators used were interpretation, analysis, evaluation, inference, explanation, and self-regulation. The items developed are adjusted to physics subjects and students' characters or abilities, but the indicators used remain the same. After validation by instrument and content experts and a simple test on a limited sample, 25 items of the CTA test were obtained. While for LO data collection, the same test instrument is used as for the CTA test, but the indicators used are indicators in the syllabus of physics subjects for the subtopic of harmonic oscillation.

2.6. Data analysis
Analysis of CTA and LO data used descriptive statistics, N-Gain and t-test. Analysis with descriptive statistics was used for the initial analysis of the two data followed by N-Gain analysis and t-test. Meanwhile, the N-Gain analysis was used to obtain information about the improvement of the ability of CTA and LO. Meanwhile, the t-test was conducted to obtain information on the significance of the increase in CTA and LO.

3. Result and Discussion

3.1. Increasing students' critical thinking ability
Information on increasing students' critical thinking ability (CTA) can be found through data analysis using the N-Gain formula [33]. The results of data analysis of the pre-test, post-test, and N-gain mean of students' critical thinking ability (CTA) are completely shown in Table 1.

| No. | Indicators | Pre-test | Post-test | N-gain | Criteria N-gain |
|-----|------------|----------|-----------|--------|-----------------|
| CTA 1: 1 | Interpretation | 42.4 | 84.1 | 0.72 | High |
| CTA 2: 3,8 | Analysis | 38.6 | 86.4 | 0.78 | High |
| CTA 3: 4,5 | Evaluation | 52.7 | 72.0 | 0.41 | Moderate |
| CTA 4: 6,7 | Inference | 55.3 | 73.9 | 0.42 | Moderate |
| CTA 5: 2,10 | Explication | 49.6 | 73.1 | 0.47 | Moderate |
| CTA 6: 9 | Self regulation | 42.4 | 75.0 | 0.57 | Moderate |

Based on the results of CTA data analysis, it shows that after implementing learning activities through the STS approach there is an increase in students' CTA abilities with moderate criteria or between 0.30 < g < 0.70. Students' critical thinking ability (CTA) can also be measured per indicator in accordance with the views expressed by Irfandi [32]. Where the STS approach aims to meet the goals of scientific literacy by promoting science teaching and learning through individual contexts in society so that students acquire important science ability and the ability to think critically, make correct decisions, solve problems, work collaboratively, and be technologically efficient. The results of the analysis of the improvement in students' critical thinking ability per indicator are shown in Table 1. The results of the analysis show that the indicators of interpretation and analysis are in the high category (0.72 and 0.78). Meanwhile, the indicators of evaluation, inference, implication, and self-regulation are included in the medium category. There is an increase in interpretation and analysis indicators because the STS approach is focused on higher order thinking ability, engaging students in problem solving, students engaging in discussions related to real problems and technology [34]. These findings are consistent with the research conducted by Jariyah [35], namely that the STS approach is able to improve students' critical thinking ability, because the STS approach focuses more on technology and society in learning science logically. Utami [36] also reported the same finding, where the STS approach was able
to increase the average critical thinking ability of students from an initial value of 69.96 to 75. Likewise, Suteja [37] has proven that there is a very significant difference in learning using the STS approach with the results of the t-test = 2.725 with $p = 0.009$. The statistical test was conducted to test the hypothesis about the average critical thinking ability of students through the STS approach to harmonious vibration material. The results of the analysis prove that before and after applying the STS approach to the harmonic vibration material there are significant differences, through the analysis of the average difference test, as shown in Table 2.

### Table 2. The difference the pre-test and post-test mean of students’ critical thinking ability.

| Data    | Mean Score | Normality*          | Homogeneity**       | Significanion***      |
|---------|------------|---------------------|---------------------|-----------------------|
| Pre-test| 54.7       | $X^2_{hit} > X^2_{tab}$ (12.99) > (11.1) | $F_{hit} < F_{tab}$ (3.54) > (1.90) | $t_{hit} < t_{tab}$ (14.84) > (1.70) |
|         |            | (not normally distributed) | (homogen)           | (real different)      |
| Post-test| 87.8       | $X^2_{hit} < X^2_{tab}$ (5.32) < (11.1) |                       |                       |
|          |            | (normally distributed) |                     |                       |

Based on the results of the t test in Table 2, it proves that there are real differences before and after applying learning through the STS approach to harmonious vibration material. The results of the data analysis prove that the STS approach can improve students' critical thinking ability. The real difference in increasing CTA through the CTA approach is also supported by the findings of previous researchers, including Afni [38], saying that there are differences in students' critical thinking abilities using the STS approach with $t_{count} = 11.15 > t_{table} = 2.56$ and Rachmawati findings [39] there is a significant difference in critical thinking ability through the STS approach. Based on the results of this study and some of the previous findings it can be said that critical thinking ability (CTA) need to be integrated in learning as an objective of the learning process. Because it can provide experience to be able to compete in the future and can also prevent misunderstandings in understanding the concept of science and technology [40, 41, 42, 43].

### Table 3. The difference the average pre-test and post-test learning outcomes (LO) of students.

| Data    | Mean Score | Normality*          | Homogeneity**       | Signification**      |
|---------|------------|---------------------|---------------------|----------------------|
| Pre-test| 60.0       | $X^2_{hit} > X^2_{tab}$ (30.8) > (11.1) | $F_{hit} < F_{tab}$ (1.35) < (1.90) | $t_{hit} < t_{tab}$ (18.14) > (1.70) |
|          |            | (not normally distributed) | (homogen)           | (real different)      |
| Post-test| 88.3       | $X^2_{hit} > X^2_{tab}$ (16.1) > (11.1) |                       |                       |
|          |            | (not normally distributed) |                     |                       |

3.2. **Improved student learning outcomes (cognitive)**

The learning process with the STS approach can develop students' cognitive abilities in mastering the basic concepts of science, especially in the matter of harmonious vibrations. The increase in students' initial and final abilities in the cognitive domain was significantly different between before and after the STS approach was applied. The results of the analysis of the average difference test between the pretetst
and post-test are shown in table 3. Both data (pre-test and post-test) have good homogeneity, but the distribution of the two data is less normal or not normally distributed, because the calculated X value is greater of the X values in the Table 3. Based on the results of the analysis in the table, it shows that student-learning outcomes in the cognitive domain have significant differences. The results of the analysis prove that after implementing learning activities through the STS approach there is a significant increase in learning outcomes. These findings are supported by the results of previous studies where after the application of the STS approach student learning outcomes increased and the score ≥ 75 was above 85% [6]. Other findings indicate that there is an increase in student learning outcomes, and it is proven by the results of the N-gain test for each indicator in the cognitive aspect of experiencing a difference in improvement [44].

3.3. Response of student

Student responses to the implementation of learning using a positive STS approach and feel happy learning the concept of harmonious vibrations. One of the reasons is because students can direct their own learning methods so that it is easier to understand the concept of harmonious vibrations being learned and work on the given questions. Previous researchers have also experienced positive responses such as the results of this study related to the application of the STEM approach learning model [45, 46], implementation of practicum modules [47], student's worksheet scientific approach [48], EduPlaza interactive media [49] and integrated PBL with EiE [50].

4. Conclusion

Based on the results of the study, it can be concluded that the application of the STS approach can improve students' critical thinking ability (CTA) on harmonious vibration material. The results of the data analysis prove that the increase in student CTA on average is moderate. The results of the analysis per indicator indicate that the indicators of interpretation and analysis are considered high criteria, while evaluation, inference, implication, and self-regulation are categorized as moderate criteria. The results of the analysis also prove that the application of the STS approach can improve student learning outcomes on harmonious vibration material at high criteria. Student and teacher responses are relatively good and positive, especially related to the discussion and question and answer phase regarding examples of technology on the topic of harmony oscillations.

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