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Role of Teaching Strategies in Promoting Students' Higher Order Thinking Skills and Critical Thinking Dispositions

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Abstract. One of the causes of students' low higher level thinking abilities is the use of teaching strategies. This research aims to investigate the role of higher order thinking skills teaching strategies to improve students' critical thinking skills in science learning. The research design used was quasi-experimental by dividing students into three groups, namely the experimental class which received teaching strategy intervention that encouraged higher level thinking skills, while the other two groups were students majoring in science and non-science who received traditional teaching intervention. The participants involved were 300 vocational school students. The instruments used in this research are critical thinking skills assessment instruments, dispositions observation sheet of teaching strategies used by the teacher, and question sheets that reveal the teacher's perspective on higher order thinking skills. Quantitative analysis was applied to the data and included descriptive statistics and ANOVA tests and was strengthened by qualitative data analysis using analysis of interview results. Research findings show that students in the experimental group showed significant improvements in all components of critical thinking and dispositional aspects. The increase in critical thinking skills appears significant in all aspects, namely evaluative, identification and inference. Improvements in the disposition aspect can be seen in the ability to seek the truth, the ability to open one's mind, self-confidence, and maturity in facing problems. In addition, teaching designed to improve high-level thinking skills has intensity in several activities such as always presenting problems in context, open discussions, encouraging students to experiment, being inquiry-oriented, and providing many opportunities to develop critical thinking skills. This research means that students' critical thinking abilities can be improved by designing teaching that integrates several methods that encourage them to think critically. Researchers recommend the need for teacher professional development programs, especially in the use of teaching strategies that encourage higher order thinking skills in the teaching process.

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1. Introduction

Students' higher-order thinking skills are influenced by various factors, one of the main ones being the teaching strategies used by teachers. This teaching strategy really determines students' thinking habits in solving problems in the classroom. Teachers who more intensively use teaching strategies that encourage higher order thinking skills will make students accustomed to solving problems that require such skills. However, if teachers rarely use teaching strategies that promote higher-level thinking abilities, it will cause students to have difficulty solving high-level problems. Developments and changes in the world demand students' abilities to be increasingly complex and high level , so that teaching is needed that must be able to improve higher-order thinking skills, such as critical thinking skills, making the right decisions, and problem solving skills (Kabataş Memiş & Çakan Akkaş, 2020; Podina et al., 2020). This high-level thinking ability or high-level cognitive ability can be developed by facilitating students to understand and explore knowledge and being able to make them responsible for their knowledge, actions, and roles, both in the classroom and in social life (Eisenman & Payne, 2016; Pettersson, 2020). Some of the abilities that need to be developed in students in order to face challenges are the ability to think critically, analyze new situations, the ability to ask questions, solve problems and make decisions based on rational and logical thinking frameworks (Beckwith, 2019; Danvers, 2018).

Even though, currently, teachers have received education regarding reform and proper teaching strategies, the majority of these teaching strategies are not used by teachers because teaching designs that are able to encourage students' higher-order thinking skills require good teaching skills (Lo & Feng, 2020; Lu, Pang et al., 2021). Some teachers still carry out a learning process which is dominated by the use of low-order thinking skills, resulting in many students being unable to solve questions that require high-level thinking skills. This is evidenced by the low level of student literacy in the international arena (PISA and PIRLS) (Hadianto et al., 2021a; Mukhdor, 2020). The majority of students are unable to solve problems that have a high level of thinking ability, they are only able to solve questions that are at a low level (Eisenman & Payne, 2016; Hadianto et al., 2022). The teacher's obstacles in carrying out a teaching process that promotes higher order thinking skills are ignorance of strategies that are appropriate to the material, the inability of the teacher to design learning procedures, the inability to utilize simple facilities and infrastructure, and limited time. Therefore, it is necessary to design teaching strategies that are able to encourage higher-order thinking skills to improve students' critical thinking skills.

Several previous studies have mostly focused on students' critical thinking skills at the secondary school level in various fields (Hwang et al., 2023; Noone & Hogan, 2018a; Suseelan et al., 2022). However, there has been no research that reveals aspects of the ability and disposition of critical thinking skills at the same time in the field of science in secondary schools. So, the difference between this

research and previous research is the focus of the study, which not only focuses on investigating aspects of critical thinking skills, but also on aspects of the disposition of critical thinking skills. Given the importance of developing critical thinking skills, the purpose of this study was to examine the effectiveness of teaching strategies that promote higher order thinking skills in improving students' critical thinking skills. Teaching that is designed to deliberately promote higher-order thinking skills is also believed to be able to increase students' dispositions toward critical thinking skills (Lee & Lai, 2017; Moghadam et al., 2023). Based on the research background, the researcher formulated several research questions in this study, namely: 1) What is the role of teaching higher order thinking skills on students' higher order thinking skills and dispositions? 2) What is the teachers' perception regarding the concept of critical thinking skills? 3) What are the characteristics of teaching strategies that encourage students' higher order thinking abilities?

2. Literature Review

2.1 Higher Order Thinking Skills

Educational reforms that promote higher order thinking skills stem from a constructivist view of designing learning processes. This reform requires teachers to transform the teaching strategies used from traditional book or text-based teaching strategies, memorization, into learning strategies based on scientific inquiry and material exploration in real-life contexts (Maiese, 2019; Noone & Hogan, 2018b). This constructivist theory encourages students to obtain meaningful learning experiences, meaning that the learning process must be able to encourage students to construct their knowledge and improve their own thinking skills through the learning process they go through (Limniou et al., 2018; Prakash & Litoriya, 2022). Promotion of level thinking in the learning process has recently become the focus of educational programs due to the demands of the times. Some experts call higher order thinking skills high cognitive abilities, but all of these terms have the same meaning referring to the ability to think at a higher level in solving problems (Hwang et al., 2023; Suseelan et al., 2022). Higher-order thinking skills are non-algorithmic complex thinking skills that are capable of generating various alternative solutions to solving problems. This higher-order thinking ability involves several aspects, namely uncertainty, paying attention to various criteria, reflection, and self-regulation (Lee & Lai, 2017; Lu, Yang et al., 2021). This high-level thinking ability is in accordance with the concept of Bloom's and Kratwohl's taxonomy (Sheffield, 2018; Shpeizer, 2018).

The ability to remember is an example of low-level cognitive abilities, while higher-order thinking skills include the ability to analyze, evaluate, and synthesize, which are alternatives to higher-order thinking skills (Southworth, 2022; Sung et al., 2019). Learning processes that are able to provide learning experiences for higher order thinking skills can equip students with the ability to solve problems, draw conclusions or decisions, predict solutions to problems, make generalizations of solutions, and have the ability to think creatively (Moghadam et al., 2023; Teimourtash & YazdaniMoghaddam, 2017). In addition, examples of other abilities that are included in higher-order thinking skills are the ability to ask critically, think critically, and think systemically (Puig et al.,

2019; Verburgh, 2019). There are various methods to encourage students to improve their higher-order thinking skills, but in this study the researcher describes an outline pattern that explains various forms of higher-order thinking, namely critical thinking, systemic thinking, and creative thinking (Podina et al., 2020; Rauscher & Badenhorst, 2021). In relation to the application of constructivist theory in this school, higher order thinking skills are defined as a meta-objective regulatory strategy; while the ability to think critically, systemically and think creatively is a technique or activity that must appear during the process to achieve the goals of the learning process (Eisenman & Payne, 2016; Pettersson, 2020).

2.2 Critical Thinking Skills

Critical thinking ability is the ability to control one's own thinking to think reflectively and logically to make decisions that one must believe or do. This critical thinking ability is a form of operational higher-order thinking ability that can be measured and validated. The ability to think critically in the process involves various competencies, such as validating information sources and their credibility, analyzing the suitability of new information with their schemata, and drawing conclusions from the results of critical thinking (Hadianto et al., 2021b; Kabataş Memiş & Çakan Akkaş, 2020). This critical thinking ability is very important in promoting metacognitive understanding. The ability to think critically has several meanings and concepts, including the ability to investigate a concept based on existing evidence or facts; the ability to draw valid conclusions, abstracts, and generalizations based on evidence and logic; and the ability to use some of these competencies in learning new things (Aston, 2023; Danvers, 2018). Critical thinking ability is also defined as the ability to think evaluatively with result orientation, logic, rationality, and reflectiveness in deciding to accept or reject concepts, make decisions, and act and be responsible for decisions and their consequences (Danvers, 2021; Ennis, 2018).

From previous studies, it was found that critical thinking skills are very necessary because most students are unable to use their reasoning skills when solving complex problems (Gottlieb, 2022; Hollis, 2023). It can be said that the ability to think critically is one of the key requirements for a successful life in modern times because of increasingly rapid changes in the complexity of various information and knowledge. Individuals are not required to know their position but must be able to place themselves in various contexts and are more often required to make decisions rationally based on the results of critical and evaluative thinking rather than just being asked to accept something (Maiese, 2019; Miedijensky et al., 2021). Therefore, students must be equipped with the ability to ask questions about the truth, raise doubts, see situations and conditions, and provide alternative decisions both in solving problems at school and in everyday life. This is in accordance with the theory which states that critical thinking skills cannot be obtained through teaching based on formal logic processes, principles and axioms (Noone & Hogan, 2018b; Park & Song, 2020). Through previous research, several experts confirm that critical thinking skills can be achieved through a teaching approach that encourages students to find more solutions to problem solving (Limniou et al., 2018; Prakash & Litoriya, 2022). This approach emphasizes higher order thinking skills. Critical thinking

skills are divided into two groups, namely abilities and dispositions. The ability group includes analytical, evaluative, and inference abilities, while the disposition group includes motivation, inclination, and encouragement to actively participate in thinking critically about problems, drawing conclusions, and solving problems (Loyens et al., 2023; Wijnen et al., 2022). This concept is important in assessing critical thinking skills which not only assess aspects of their abilities, but also assess aspects of students' dispositions toward their critical thinking skills because students who have critical thinking skills have a tendency to apply their critical thinking skills in various contexts.

3. Methodology

3.1 Research Design and Participants

This study used an experimental research method with a quasi-experimental design to test the effectiveness of teaching strategies for higher-order thinking skills in improving students' critical thinking skills (Lu, Yang et al., 2021). The research approach used is quantitative and qualitative. Quantitative main data are supported by qualitative data and reveal the teacher's role in designing teaching strategies and formulating critical thinking concepts based on the teacher's perspective. The participants involved in this study were 300 vocational school students with a percentage of 50% for girls and boys, respectively. Students were divided into three groups, namely group A experimental (n = 100) was a group of science students who received teaching strategy interventions by promoting higher-order thinking skills; group B, control (n = 100) was a group of science students who did not receive intervention; and group C (n-100) was the group of non-science students who did not receive the intervention. Selection of the sample was by using purposive sampling technique in grades 2 and 3 of vocational school. This study uses two science and non-science control groups to investigate whether students' dispositions toward critical thinking skills are influenced by differences in scientific disciplines or not. The intervention is carried out for one year, or two teaching semesters. Intervention teaching used teaching strategies to promote higher-order thinking skills performed on science subjects, while the control group learned by teaching as usual, which does not promote higher-order thinking skills. Researchers acted as external researchers in interviewing science and non-science teachers, observing the learning process in class. The teachers interviewed to reveal perceptions of higher order thinking skills were those who taught in the experimental group.

3.3 Instrument

The researchers used several instruments in this study to assess critical thinking skills, students' dispositions toward critical thinking skills, and was reinforced by interviews and observations to uncover qualitative data. The following describes some of the instruments and aspects assessed. The instrument used to assess critical thinking skills is the California Critical Thinking Skills Test from Facione (1992) and was adapted and validated to assess students' critical thinking skills. This instrument contains a multiple choice test totaling 35 specific non-discipline items to assess critical thinking skills. Each item of this critical thinking ability assessment instrument contains three subscales, namely

analysis, evaluation, and inference abilities. Furthermore, the instrument used to assess students' dispositions toward students' critical thinking skills is the California Critical Thinking Dispositions Inventory from Facione (1992), which was adapted, developed, and validated. Reliability and validity tests were carried out through empirical tests and expert judgment. Empirical tests were carried out on a number of samples and expert judgment was carried out by experts in the field of high-level skills and teaching strategies. This instrument contains 80 items which contain seven subscales, namely true search, open mindedness, analytical skills, systematic, confident, curious, and maturity. The instrument for uncovering this aspect of disposition was designed using a 6-point Likert scale. The total score from the results of the assessment of student disposition aspects of the seven subscales is in the range 80-420. Scores more than 285 indicate that students have a positive disposition toward critical thinking skills.

Data collection was also carried out through semi-structured interviews in the second semester. This semi-structured interview was conducted to identify and analyze different teaching strategies that promote higher-order thinking skills and investigate how to conceptualize critical thinking skills. Interviews were conducted with two teachers who were assessed by students and the school as having experience using teaching strategies that promote higher order thinking skills. The interview was conducted for 30 minutes. Interviews were recorded and transcribed as material for analysis. The results of the interviews were analyzed and coded for discussion with the researchers to reach a consensus. Researchers used learning modules which were used in two semesters consisting of 8-10 units each semester. This module is used in the learning process in each school, so this research is in line with the ongoing learning process in schools. Finally, observations were made in class to investigate the teaching strategies of science and non-science teachers. This class observation was carried out occasionally in the first and second semester. Data collection used a logbook for further analysis and interpretation. Class observations were carried out by researchers sitting behind students and documenting all learning process activities starting from materials, teaching methods, and interactions between students and instructors related to teaching strategies that promote higher-order thinking skills.

3.2 Procedures and Data Analysis

Rigorous tests on each phase and group were carried out to investigate the role of teaching strategies on critical thinking skills and dispositions toward students' critical thinking abilities. The design of this study will provide a comparison between the abilities of the intervention group (higher-order thinking skills approach) and the control group (traditional approach). In addition, this quasi-experimental design also provides an overview of the impact of each intervention from each phase during the study. Furthermore, quantitative and qualitative approaches can strengthen research findings. Quantitative data describe the increase in ability in each phase and group, while qualitative data can reveal perspectives regarding the teaching strategies used and the concept of critical thinking skills from the teacher's point of view. Researchers used the California Critical Thinking Disposition Inventory to assess students'

dispositional abilities toward critical thinking skills and assessment of critical thinking skills was using the California Critical Thinking Skills Test. The procedures carried out follow the research design, namely first conducting an initial ability assessment on both aspects, critical thinking abilities and student dispositions. Furthermore, interventions were carried out with teaching strategies that promote higher-order thinking skills in the experimental group and traditional teaching interventions for the control group. Finally, an assessment was carried out in the posttest phase to measure the effectiveness of the intervention. The characteristics and number of students who took part in the pretest to posttest phases were the same so that they did not affect the results and conclusions. Sample characteristics include gender, study program, and the number of learning units studied during the intervention. The use of instruments to assess critical thinking skills and dispositions was carried out separately and randomly distributed to students in the experimental and control classes. Each student completed the assessment and was analyzed. Data analysis used in this study is the analysis of the gain equation to determine the comparison of the increase in ability in each group. Analysis of qualitative data from interviews regarding perceptions of high-level thinking abilities was carried out descriptively by highlighting the concepts of high-level thinking abilities from the teachers interviewed and confirmed with theories and teaching results on the competence of students who took part in the learning process with their teachers.

4. Result

4.1. Students Critical Thinking and Disposition Abilities

From the results of the overall analysis, the scores of students' critical thinking abilities and dispositions in the experimental group showed a more significant increase in the control group. To answer the first formulation of the problem regarding the role of teaching strategies that promote critical thinking skills and students' dispositions, Table 1 is presented. Improving students' abilities in each phase, the intervention was able to develop aspects of students' dispositions toward critical thinking skills and students' own critical thinking abilities. These developments lead to the maturation stage in the learning process.

Table 1. The Mean, Maximum, Minimum, and Elementary Students' Critical Thinking Abilities and Dispositions

Aspect Disposition		N	Minimum	Maximum	Mean	SD
	Pre	300	163.24	325.22	235.12	33.41
	Post	300	175.45	382.33	321.33	43.30
	Follow-up	292	184.12	375.22	467.21	40.32
Critical thinking	Pre	300	4.25	21.43	9.83	4.45
	Post	300	8.32	26.32	17.12	4.24
	Follow-up	295	12.54	29.14	21.32	4.50

From the research results, the findings show that students' abilities, both critical thinking skills and dispositions, have increased from the pretest to the posttest phase. The average value of student dispositions in the pretest to posttest phase,

changed from 235.12 to 321.33, and the follow-up phase is 467.21. Likewise in the minimum and maximum values in the pretest and posttest phases, the minimum value of 163.24 increased to 175.45, and the follow-up phase was 184.12. The maximum value of disposition also increased in each phase, from 325.22 to 382.33, and remained stable in the posttest phase of 374.22. Furthermore, students' critical thinking skills also increased from the pretest to posttest phases in their average, minimum, and maximum scores. The average value of students' critical thinking skills in the pretest to posttest phase increased from 9.83 to 17.12, and the follow-up phase was 21.32. Likewise the minimum and maximum values in the pretest and posttest phases also increased; the minimum score of 4.25 increased to 8.32, and the follow-up phase was 12.54. The maximum value of disposition also increased in each phase, from 21.43 to 26.32, and remained stable in the follow-up phase of 29.14. The average and primary school findings of this study were found to be relatively higher than the critical thinking ability standards of senior vocational school students. Next, a paired sample t- test was carried out to see a comparison between critical thinking skills and student dispositions. Based on the results of the t-test, a significant difference was found in the pretest phase with each value (critical ability: $t(100) = 14.89$ $p<0.001$, and dispositional aspects $t(100)= 18.21$ $p<0.001$. However, as the intervention progressed, in the posttest and follow-up phases there is no difference seen between students' critical thinking skills and disposition aspects.

4.2 The Influence of Teaching Strategies on Critical Thinking Ability and Students' Disposition on Critical Thinking Ability

Based on the results of the analysis, the differences in the control group in the science and non-science groups were in the aspects of disposition and critical thinking skills in the posttest and follow-up phases. These results indicate that students' dispositions and critical thinking skills are not determined by scientific disciplines. Furthermore, significant differences were found in aspects of critical thinking ability and critical thinking ability dispositions which are presented in Table 2 and 3. From the analysis results, the majority of the experimental group's critical thinking ability scale showed the highest score in the posttest phase, which is presented in Table 2. In addition, the experimental group's critical thinking skills also showed high scores on all scales in the posttest and follow-up phases, which are presented in Table 3. This finding is the result of a teaching strategy intervention that promotes higher-order thinking skills which are not only able to improve students' critical thinking skills, but also contribute to the attitudes or habits of thinking of students during the learning process. Based on the results of the ANOVA test, the experimental group showed an increase in dispositional ability toward critical thinking skills better than the scientific and non-scientific control group with total disposition aspects ($F(2)=9.73$, $p<0.01$), with detailed details of the disposition aspect of seeking the truth ($F(2)=8.35$, $p<0.01$), open-minded ($F(2)=9.12$, $p<0.01$), self-confident ($F(2)=5.40$, $p<0.02$), and maturity ($F(2)) =7.35$, $p<0.01$). Furthermore, from the results of the ANOVA test, the critical thinking skills of students in the science control group experienced an increase only on several scales, and the non-science control group showed the lowest score on the critical thinking ability scale. The experimental group also showed a significant increase in critical thinking skills more than the science and non-science control group with a total ($F(2)=12.13$, $p<0.01$) with a detailed

evaluation scale ($F(2)=6.31$, $p<0.01$) and inference ($F(2)=9.40$, $p<0.01$). These findings indicate that teaching strategies by promoting higher-order thinking skills can improve critical thinking skills in all aspects of seeking the truth, open-mindedness, confidence, and maturity, so as to make students wise in drawing conclusions. Teaching by promoting higher-order thinking skills can improve students' critical thinking skills, which include evaluative, identification, and inference abilities.

Table 2. Average and Elementary School Disposition on Students' Critical Thinking Ability based on Subscales and Groups

Disposition Aspect	Experiment N=100 Mean (SD)			Control Science N=100 Mean (SD)			Control Non-science N=100 Mean (SD)		
	Pre	Post	Follow-up	Pre	Post	Follow-up	Pre	Post	Follow-up
The Search for Truth	32.24 (6.12)	41.68 (7.40)	40.51 (7.22)	31.35 (4.45)	36.54 (7.21)	35.33 (6.61)	28.85 (6.30)	32.50 (6.50)	35.46 (7.25)
Open-mindedness	30.45 (6.72)	39.32 (6.81)	40.65 (7.61)	32.51 (5.20)	36.40 (4.24)	38.51 (5.14)	34.56 (6.50)	36.43 (5.78)	35.35 (5.78)
Confidence	27.61 (6.30)	42.50 (7.23)	45.52 (8.45)	31.03 (6.40)	42.60 (4.62)	39.86 (5.50)	31.23 (7.20)	38.56 (7.12)	36.27 (6.85)
Maturity	32.62 (5.67)	41.14 (6.67)	40.78 (6.74)	32.80 (5.24)	36.46 (5.74)	36.98 (5..02)	30.62 (6.12)	36.92 (6.30)	37.82 (6.20)
Total	225.64 (28.92)	297.90 (44.32)	289.63 (42.56)	236.60 (36.31)	280.78 (38.70)	283.89 (36.50)	237.10 (37.62)	276.64 (41.82)	275.24 (38.80)

Table 3. Average and Elementary Scores of Students' Critical Thinking Ability based on Student Subscales and Groups

Critical Thinking	Experiment N=100 Mean (SD)			Control Science N=100 Mean (SD)			Control Non-science N=100 Mean (SD)		
	Pre	Post	Post–post	Pre	Post	Post–post	Pre	Post	Post–Post
Analysis	4.42 (1.40)	6.78 (2.40)	6.50 (1.78)	3.90 (1.32)	5.12 (1.20)	5.23 (1.30)	3.23 (0.80)	4.20 (0.83)	5.76 (1.24)
Evaluation	3.40 (2.14)	8.40 (2.68)	10.45 (0.89)	4.65 (1.90)	5.25 (1.34)	7.24 (2.15)	3.42 (2.12)	4.50 (1.20)	6.78 (1.68)
Inference	4.72 (1.90)	8.42 (2.50)	7.93 (0.82)	3.64 (1.52)	6.24 (1.52)	6.45 (1.62)	3.80 (1.32)	5.34 (1.26)	6.03 (1.45)
Total	9.92 (3.50)	21.40 (3.24)	25.50 (2.25)	9.89 (2.72)	16.31 (2.62)	19.62 (3.40)	10.80 (3.43)	14.14 (2.82)	16.20 (3.45)

4.3 Teaching Strategies and Conceptualization of Critical Thinking Ability based on Teacher Reflection

To investigate teaching strategies and the concept of critical thinking skills based on the instructor's perspective, semi-structured interviews were conducted with the science instructor in the experimental group. The two instructors were coded Teacher A and Teacher B. The interviews were conducted with a focus on the use of teaching strategies and the conceptualization of critical thinking skills. A is a young teacher who has six years of teaching experience. He has a bachelor's

degree in chemistry education and a master's degree in natural science education. Instructor A often takes part in various workshop activities to develop his pedagogical abilities both related to teaching strategies and field abilities. Teacher A is one of the model teachers in his school based on information from other teachers and students in his school.

B is a fairly experienced teacher and holds a master's degree in chemistry education. Instructor B has 23 years of teaching experience. In addition, teacher B is also a member of school management. Teacher B is also often involved in science teacher professional education, either as a participant or teacher, and active in developing science teaching materials in his school. These two teachers, A and B, became samples of qualitative data collection to investigate teaching strategies that promote higher-order thinking skills and the concept of critical thinking skills based on their perspectives. The interviews were conducted separately, so they were not known to each other. Based on the results of the interviews, teachers A and B provide a global and holistic view by explaining the importance of the thinking skills as a whole and connecting science with students' real lives. Furthermore, the teaching strategy used in general is inquiry-based experiments that are linked to life contexts. With this strategy, the two teachers believe they have promoted higher-order thinking skills in their learning process. The following is teacher A's statement regarding the teaching strategy he used:

I encourage students to do a number of activities such as asking questions, investigating phenomena, providing assumptions or reasoning… New concepts are taught by relating them to real-life contexts. I not only provide new knowledge, but also invite students to think.

Teacher A also attaches importance to the relationship between science concepts and students' real lives. Here's the statement:

The way that can be done to connect science with students' lives is to connect science concepts with various phenomena that often occur in real life. For me, Sara is a big challenge in teaching. I often make this connection in biology, in studying various activities of living things, and chemistry by using various existing substances such as acids and bases, the PH in certain liquids, and various others.

From the results of the interview with teacher A, he did not provide any disciplinary boundaries. Furthermore, when asked for his views on the concept of critical thinking skills teacher A responded:

In my opinion, the ability to think critically is a method to control the ability to think by using logic. Through critical thinking skills, I hope students can solve the problems they face using a systematic method. It is hoped that students will provide assumptions and draw conclusions based on the knowledge, schemata, and tools taught in the learning process.

The concept of critical thinking skills that he puts forward is almost similar to the theory of critical thinking skills which defines critical thinking skills as the ability to think logically and reflexively. Next, he answered questions about the importance of critical thinking skills:

In my opinion, the ability to think critically in learning mathematics and science is very important. Critical thinking skills are also very important in learning other disciplines. However, critical thinking skills are very important to use in real life contexts and have the tools to use them.

The results of interviews with teacher B also stated the same thing as per the following statement: *Teaching science is not only to teach facts and figures, but also to teach critical and creative thinking*.

Teacher B had difficulty when asked about the concept of critical thinking skills in his view:

It is quite difficult to give a definition of critical thinking skills. Critical thinking ability is the ability of students to reflect on their thoughts in understanding a concept and assist them in making decisions.

One of the goals of teaching according to teacher A is to motivate students in learning. The goal is the same as teacher B, which is to enhance the experience and foster students' positive emotions toward science:

I want my students to live life using science. That way, my teaching has a positive impact on students' feelings about the benefits of science.

Teacher B also frequently uses a variety of teaching methods and aids:

I use various teaching methods in the learning process such as short videos, stories, magazine articles, scientific articles, experiments, individual assignments, and group assignments. One example is that I encourage students to be able to use plastic molecule models so that students can experience the spatial structure of molecules firsthand.

Similar to teacher A, teacher B also connects science in the learning process with students' daily lives:

In the learning process, I explain science concepts related to real-life phenomena. For example, protein teaching is done using the student's hair structure. Teaching oxidation and reduction using hair dye or other alternatives, for example the function of the battery. Teacher B also does not only use real-life phenomena, but invites students to conduct hands-on experiments, such as studying CO2 release using cold or warm cola bottles.

When asked about the concept of critical thinking skills based on the perspective of teacher B, he answered that the most important part is growing students into citizens who are able to utilize science concepts in real life.

4.4 Characteristics of Using Teaching Strategies that Promote Higher Order Thinking Skills to Improve Critical Thinking Skills

To find out the characteristics of the teaching strategy used, observations were made in each semester carried out randomly in the classrooms of teacher A and teacher B. From the observations, there are several findings including the two teachers connecting science concepts with everyday life, the teachers also integrate learning with using the inquiry model, and give students opportunities to discuss and think critically by asking open questions. Some examples of

questions used and related to real-life contexts in class include oxidation and reduction materials related to everyday life, namely "Is iron rusting an oxidation-reduction reaction?"." Iron will rust faster in which area? and "How to prevent oxidation reduction?" Through these questions, students are given the opportunity to explore the question. In addition, based on the results of observations, it was found that there are three main teaching strategies that are often used by the two teachers, namely the strategy of connecting with the original and interdisciplinary context, the strategy of open discussion, and short group experiments. The teacher used this strategy in the intervention phase, leading critical thinking skills and students' dispositions to increase significantly, especially in the aspects of seeking the truth, open-mindedness, self-confidence, and maturity, while the abilities that increase in the aspect of critical thinking skills are the ability to evaluate and infer as can be seen in Table 3. The researcher presents several statements that describe the teaching strategies used by teacher A. The strategies used by teacher A have similarities to teacher B. The following are some quotes from students in the class taught by teacher A in the experimental group. Teacher A took a real-life case to solve a relevant problem at the start of the session and provided an example from his personal life that was relevant to the problem. Next, the teacher asked questions that encouraged students to think critically about the relationship between the situation and the science concepts they have learned.

Teacher A: Yesterday I visited a friend's house who was planting peanuts. When I came home, he gave me quite a lot of nuts. I heard these nuts will make me fat. What should I do before I decide whether to consume it or not?

Student 1: You have to check the calories contained in peanuts in every 100 grams.

Teacher A: How to check? Do you have any suggestions? Can anyone explain and relate this to the material we studied last week? What experiments should we do to check these peanut calories?

From the dialogue excerpts from the teacher and students above, we can explain that teacher A uses teaching strategies that can encourage students to think critically to solve problems. The teacher and students used several sessions to calculate calories using different chemical reaction enthalpies and analyze the number and types of bonds formed and broken. Furthermore, teacher A also asked several other questions such as:

What types of energy are you familiar with? Our bodies need energy; think about what this energy is for? And what activities lead to reactions of chemical compounds in it?

Teacher A also introduced new material and concepts in the learning process as well as related them to concepts that had been discussed previously with other topics that are still related and in accordance with real-life contexts. The teaching strategy used in the learning process is able to improve cognitive abilities, so that students are able to strengthen and revise assessments, and thinking systems.

Teacher A: What is a chemical bond? What chemical reaction is written on the blackboard? How many bonds must we break and make for a chemical reaction to occur? What form of energy can be produced from this chemical energy reaction?

In the learning process, teacher A asked lots of questions that can encourage curiosity and encourage students to formulate their own problems. The teaching strategy used aims to increase students' curiosity so that students are encouraged to seek information and obtain relevant alternative solutions. The aspect of the disposition that emerges from this process is the search for truth.

Teacher A: Now your task is to formulate problems related to peanuts and use concepts related to chemical reactions and energy transfer.

Student 2: We learned from peanuts how to calculate the enthalpies of different reactions and wrote down all the data it needed in the textbook, such as bond enthalpy, heat capacity, and how can we get these data?

Student 1: What chemical components do peanuts consist of?

Teacher: Good question, think about more questions.

Student 3: Are the peanuts raw or burnt?

Student 4: That's not a question, is it important to ask?

Teacher A: There are no silly questions or stupid ideas in class. Actually, that is one very good question. Think about why this question is a good question? Recall the inquiry experiment you did last week.

Teacher A increased students' confidence in expressing their ideas and opinions freely and prevented classmate intolerance. This teaching strategy increased students' trust and confidence in their own reasoning abilities. Aspects of the disposition of critical thinking skills are characterized by self-confidence. In addition, teaching strategies can also help short inquiry experiments in groups and train students to work together in groups.

Teacher A: Let's check the number of calories in my peanuts. Try your group in pairs or with three people. Try to think about the problem, the experimental design, and consider the equipment, hypotheses, and instruments needed. I want you to think about this in individual groups and explain it up front. Please discuss to answer all these questions.

From this quote, teacher A was able to increase student cooperation in groups, exchange ideas, and collaboration in conducting inquiry-based experiments. The teaching strategy used aims to develop students' ability to understand their friends' ideas and evaluate them. The disposition aspect that appears in the quote is an open mind in accepting the ideas or opinions of friends in the group.

5. Discussion

Aspects of students' disposition after receiving interventions with teaching strategies that promote higher-order thinking skills experienced a significant increase in all categories, namely truth-seeking, open-mindedness, self-confidence, and maturity. Improved aspects of student dispositions were seen in

the posttest phase and were still stable in the follow-up phase. This result is due to the teaching strategy used by the teacher being able to encourage students to cultivate aspects of this disposition (Saido et al., 2018; Sheffield, 2018). Open class discussions, experiments, inquiry, and group work can improve students' dispositions. This process is carried out consistently to make students accustomed to the disposition as well as to using higher order thinking skills. This is consistent with the theory that teaching strategies that encourage higher order thinking are not only able to improve students' critical thinking skills, but will also form a good attitude or positive disposition toward critical thinking skills (Southworth, 2022; Sung et al., 2019). Students' critical thinking skills increased in the posttest and follow-up phases. The improvement was significant in all aspects, namely evaluative, identification and inference. The most significant improvements appeared in the evaluation and inference. This finding is consistent with previous studies which confirmed that critical thinking skills can be improved through open discussion and inquiry methods (Lee & Lai, 2017; Moghadam et al., 2023).

From the results of the intervention, the increase in critical thinking skills and students' dispositions was not much different. This proves that an increase in students' critical thinking skills will always be followed by a good disposition toward students' critical thinking skills. In addition, the increase in critical thinking skills and student dispositions in science control classes and non-science control classes taught using traditional strategies were not much different. These findings indicate that improving critical thinking skills is not influenced by disciplinary differences, but is influenced by the teaching strategies used, as found in previous research (Beckwith, 2019; Pettersson, 2020). These findings indicate that critical thinking skills and dispositional aspects are not determined and influenced by scientific disciplines. This is in accordance with the theory that the improvement of critical thinking skills is determined or shaped by the teaching strategies used by the teacher, not by the disciplines being studied (Aston, 2023; Dolapcioglu, 2020). From the results of observations, there are three teaching strategies used in the experimental class and strategies that are able to promote higher-order thinking skills, namely real-world context strategies, open class discussions, and inquiry-based experiments. This is consistent with the theory that a good teaching process that is able to improve critical thinking skills is a learning process that involves students actively in forming their own knowledge concepts (Eisenman & Payne, 2016; Verburgh, 2019). The findings of this research also reinforce that the majority of science and non-science teachers still use strategies that are unable to improve higher order thinking skills. This finding is proven by several facts which show that the ranking of students' higher order thinking abilities in Indonesia is still low (Hadianto et al., 2021b; Rauscher & Badenhorst, 2021). Conventional teaching that is still widely used by teachers will not be able to prepare students to face a changing and challenging world. The demands of this world really need students' ability to make decisions rationally and based on critical thinking skills. The teaching strategies used in the learning process carried out by teachers in the experimental group mostly integrated several strategies, namely connecting with phenomena, encouraging students to experiment with inquiry, and open discussions. Integration of teaching strategies has been confirmed in

previous research as being able to effectively improve higher-order thinking skills compared to single teaching strategies (Hadianto et al., 2021b; Puig et al., 2019).

The results of this study reinforce that teaching strategies that are varied and promote higher-order thinking skills will also shape higher-order cognitive abilities and dispositional attitudes toward those higher-order cognitive abilities. This kind of learning process will always be oriented toward investigating problems with relevant real-world information or cases. One of the teaching strategies that promote higher-order thinking skills is to convey knowledge across disciplines or different domains (Podina et al., 2020; Verburgh, 2019). However, in reality there are still many teachers who have difficulty transferring knowledge across disciplines in the learning process. The success of students in improving critical thinking skills in this research proves that cross-disciplinary teaching can be implemented and is effective in training students' critical thinking skills because the cross-disciplines used are non-general disciplines. These findings strengthen previous research which confirms that students' critical thinking skills can be improved by taking topics from other disciplinary fields (Beckwith, 2019; Danvers, 2021). This research indicates that there is a need for teacher education and development in the context of the program. Teachers who have the ability to use teaching strategies that promote higher-order thinking skills will make students successful in the future.

6. Conclusion, Implication, and Recommendation

Teaching strategies that promote higher-order thinking skills are not only able to improve critical thinking skills, but are also able to improve aspects of student dispositions. The improvement of critical thinking skills appears significant in all aspects, namely evaluative, identification, and inference. The most significant improvements appear in the evaluation and inference. The improvement in the disposition aspect is seen in the disposition to seek truth, an open mind, self-confidence, and maturity. Intensive teaching strategies carried out in the learning process are open class discussions, experiments, inquiries, group work able to improve student dispositions. This research has implications that students' critical thinking skills and dispositions can be improved by integrating teaching strategies that promote higher order thinking skills in a continuous manner. Teaching strategies that promote higher-order thinking skills can be used not only in the sciences, but also in a variety of disciplines.

This study has several limitations, including research that does not pay attention to gender variables, the non-science fields involved are still limited to the field of social sciences, the sample is not on a large scale, qualitative analysis is not optimal for taking feedback for improvement, and research is needed on students at the vocational school and college levels. This study recommends a number of things for future research, namely considering gender aspects that might affect critical thinking skills, it needs to be done in other disciplines such as languages, arts, and social sciences, the sample involved must be larger, and qualitative analysis must uncover the drawbacks of teaching strategy interventions that promote higher-order thinking skills. Based on the findings of this study, the researcher recommends that there is a need for a teacher

professional development program, especially in the use of teaching strategies that involve higher-order thinking skills and a deeper understanding of the concept of critical thinking skills. In addition, the findings of teaching strategies that are proven to be effective in improving students' critical thinking skills and dispositions can be used as an alternative for teachers in carrying out the learning process.

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