Virtual Classroom Critical Thinking as an Alternative Teaching Model to Improve Students' Critical Thinking Skills in Pandemic Coronavirus Disease Era

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Abstract: Critical thinking skills are one of the thinking skills needed to live in the 21st century and the era of the Industrial Revolution 4.0. This study aims to develop a Virtual Classroom Critical Thinking (VC2T) Model, which is valid, practical, and effective to improve students' critical thinking skills. VC2T model has six steps: problem orientation, formulation, group discussion, analysis, result discussion, and reflection. This study is a Research & Development (R & D) involving 33 high school students in Surabaya, Indonesia. Before being tested, the VC2T Model was designed based on the theory of Plomp and Nieveen and then validated by 3 (three) experts in physics education. Data were analyzed using validity by experts, implementation of teaching with the VC2T Model, paired t-test, calculation of n-gain, effect size and percentage of student responses. The results showed that the VC2T Model is: (1) valid with an average validity score of 4.14 in the high validity category; (2) practical with an average score of implementations teaching of VC2T Model 4.26 in the outstanding category; and (3) effective as indicated by increasing of students' critical thinking skills scores which are statistically significant at alpha .05, the average n-gain is .38 in the medium category, the effect size of 6.93 is in a strong category and the average students' response is 87.59 % with outstanding category.

Keywords: *Coronavirus disease, critical thinking skills, teaching model, VC2T.*

Introduction

The advances of information technology and communication are dynamic and fast, which can change the human lifestyle. In the 21st century and industrial revolution 4.0, advances in information technology and communication are progressing rapidly in various aspects of human life, including education. Education practitioners must-have 21st century abilities to assist students in mastering science in certain fields and thinking skills needed in the 21st century. The 21st century thinking skills are "4C": critical thinking, communication, collaboration, and creativity (National Education Association, 2012). Students need it to understand the information that runs very fast. In addition, critical thinking skills are also required to solve the problems in daily life and make decisions. It is because critical thinking is logical, reflective thinking, and has prior knowledge related to the problems faced by students.

The fact shows that the critical thinking skills of Indonesian students aged 15 years (junior high school) are still low; there is a possibility that these students' critical thinking skills will be carried over until they are in the high school level. A survey conducted by the Program for International Student Assessment (PISA) in 2018 shows the critical thinking skills of Indonesian children have decreased in all fields, including science. For example, in science, 40% of Indonesian students have only reached level-2 with an average score of 396, whereas the average Organisation for Economic Co-operation and Development (OECD) is 489. Although at level-2, students can remember and know scientific phenomena known to identify simple cases, they cannot reason in compiling critical explanations, so they have not been able to make conclusions. Meanwhile, to think critically, students must be at level-5, where they can use scientific concepts to explain phenomena or events that involve various causal relationships and arguments (OECD, 2019).

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On the other hand, the emergence of coronavirus disease pandemic in Indonesia on March 2020 forced all schools to switch from offline learning to online learning or distance learning (Lie et al., 2020). Meanwhile, when distance learning was implemented suddenly, teachers did not have enough time to design online classes; besides, many did not have online teaching experience (Cheong et al., 2019). As a result, only a few teachers can implement online learning with learning management systems (LMS). Still, they teach them irregularly, and they argue that "the important thing that the material is conveyed."

Based on the description, the question arises, how to improve students' critical thinking skills during the coronavirus disease pandemic? One alternative solution that can be done is by developing a teaching model that can train critical thinking skills indicators. According to Facione (2015), critical thinking skills have 5 (five) indicators, i.e.: (1) Interpretation, (2) Analysis, (3) Evaluation, (4) Inference, and (5) Explanation.

According to Thaiposri and Wannapiroon (2015) and Duran and Dökme (2016), one of the teaching models widely used to improve critical thinking skills is the inquiry teaching model. Inquiry is very influential to enhancing students' critical thinking skills, especially in teaching science (Duran & Dökme, 2016). However, the inquiry teaching model has some limitations. It has not been applied using information and communication technology (ICT), while ICT is the main key in 21st century teaching (Williams et al., 2017). In addition, the inquiry model has not trained students yet to think and work on their own initiative and does not give students the freedom to learn according to their learning style (Taruh et al., 2019). To be able to fulfill the limitations of the inquiry teaching model during the coronavirus disease pandemic so that the teaching is in accordance with 21st century teaching and industrial revolution 4.0, improvements are needed by using distance online teaching to train students' critical thinking skills called blended learning model (Motlan et al., 2016; Zain and Jumadi, 2018). According to Harahap et al. (2019), the blended learning model can improve students' critical thinking skills. Still, teaching with the blended learning model has limitations; namely, there is no phase of reflection activities such as assessing or reflecting on ongoing teaching activities (Hairida, 2016).

Based on the problems identified, this study aims to develop a Virtual Classroom Critical Thinking (VC2T) model to improve students' critical thinking skills in physics lessons in the coronavirus disease pandemic era. VC2T is a teaching model that combines an inquiry model and a blended learning model by refining the limitations of the inquiry model and blended learning model.

Literature Review

Inquiry Learning Model

The term inquiry comes from the English word inquire, which means to ask or investigate. In inquiry learning, questions are the core of this model (Duran & Dökme, 2016). The Questions can lead students to conduct investigations in an attempt to understand the teaching material.

The inquiry teaching model is one of the models that fill the needs and challenges of education in the 21st century (Jeffrey et al., 2014). The inquiry teaching model is a series of teaching activities that focus on critical and logical thinking processes to solve the problems given (Motlan et al., 2016). Teaching inquiry in science emphasizes the involvement of students in cognitive processes such as asking questions, generating hypotheses, designing investigations, collecting and analyzing data to answer the questions, and communicating and justifying explanations (Williams et al., 2017).

There are five phases in the inquiry teaching model, namely: (1) formulating problems, (2) formulating hypotheses, (3) collecting data, (4) testing hypotheses, and (5) making conclusions (Friesen & Scott, 2013). The National Science Education Standards (NSES) states that five main things that must be filled in an inquiry class, i.e.: (1) students have to make scientifically oriented questions, (2) answer a question using appropriate evidence, (3) formulate an explanation of facts, (4) linking explanations to scientific knowledge, and (5) communicating and justifying explanations (Mokiwa & Nkopodi, 2014).

Blended Learning

The combination of face-to-face learning carried out in the classroom with online learning that can be carried out outside or inside the classroom is called blended learning (Changwong et al., 2018; Motlan et al., 2016). The blended learning model is a model that can answer the challenges of teachers in the 21st century (Zain & Jumadi, 2018). Research conducted by Marsh (2012) shows that blended learning provides teaching in a flexible format and style using technology, which can help students improve critical thinking skills needed in the 21st century. In addition, mixed strategies can increase student engagement by online activities that align with the curriculum and are effective and time-efficient. Husamah (2015) describes several characteristics of the blended learning teaching model, namely:

1) combines several teaching models, teaching methods, and various types of media that are based on technology,
2) combines independent teaching, face-to-face teaching, and online teaching,
3) is more active and student-centered.

Blended learning is needed when 1) the teaching process utilizes virtual world technology by adding the teaching time and face-to-face, 2) accelerating and facilitating the communication process without boundaries between teachers and students, 3) assisting the learning process.

Critical Thinking Skills

Thinking is an activity that uses the mind to assess and decide something; thinking becomes a bridge between new knowledge and previous knowledge. Facione (2015) explains that a person's thinking ability consists of basic thinking and higher-order thinking. Basic thinking is the ability of someone to think, which only uses memory to memorize, understand concepts, and know ideas. In comparison, high-level thinking is the ability to think related to critical thinking and creative thinking. Critical thinking uses cognitive skills to determine an increase in the results to be achieved (Halpern, 2014). When the students think critically, the students are encouraged to think independently, make hypotheses, analyze, and synthesize an event. Then the students are asked to create new hypotheses and test them. Critical thinking skills are the most important skills in education because critical thinking skills can be used to advance the world and create new knowledge (Halpern, 2014). There are 5 (five) indicators and operational definitions of critical thinking skills shown in Table 1.

Table 1. Indicators and Operational Definitions of Critical Thinking Skills

No.	Indicators of Critical Thinking Skills	Operational Definition
1.	Interpretation	Understand and express the meaning of various situations, experiences, events, data, judgments, conventions, procedures, rules, or criteria
2.	Analysis	Identify intended inferences and actual relationships between concepts, descriptions, statements, or other forms of representation intended to express experiences, opinions, reasons, judgments, or information
3.	Evaluation	Assess the accuracy of a statement which a judgment, experience, description perception, situation, or opinion to assess the logical of actual inference relationship or intended relationship between descriptions, statements, questions, or other forms of representation
4.	Inference	Identify and obtain the elements needed to draw reasonable conclusions; make a guess and hypotheses; reflect appropriate information, and mitigate the consequences of statements, data, evidence, or other forms of representation.
5.	Explanation	State and justify the reasons based on the methodological, evidence, conceptual, criteriology and contextual that form the basis; and to give reasons for someone in the form of a convincing opinion

Source: Adoption from Facione (2015)

Methodology

This study is a research development to produce a product which is VC2T Model with the following criteria: valid, practical, and effective (Van den Akker et al., 2013). This criterion is based on Plomp and Nieveen theory regarding the requirements for a good instructional design. Therefore, the VC2T Model was developed according to these criteria. The steps for developing the VC2T Model can be seen in Figure 1.
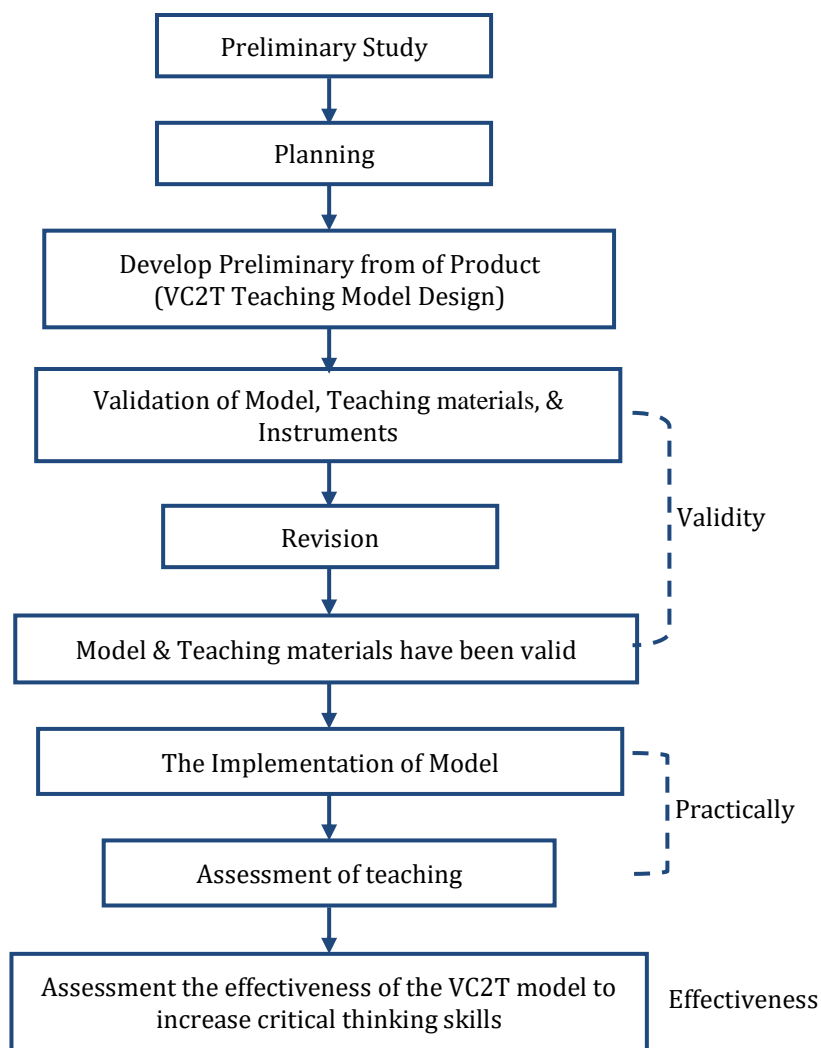
Figure 1. The plot of Development of VC2T Model

The first phase implementation of the VC2T model was conducted at a private high school (SMA Dr. Soetomo) in Surabaya, Indonesia, involving 33 students in grade 10. The first phase implementation was performed using a one-group pre-test and post-test design. Before teaching with the VC2T Model, students are given an initial test (pre-test) of critical thinking skills, and after the implementation of the VC2T Model, students are given a final test (post-test) with the same test. The first phase implementation was carried out in 5 (five) meetings; the learning topic is about heat transfer.

Implementation of VC2T Model

The syntax of the VC2T model consists of 6 phases, i.e., problem orientation, formulation, group discussion, analysis, discussion of results, and reflection. At the problem orientation stage, students are given a problem related to real-life, which is used to generate student motivation by linking the prior knowledge with the new knowledge. Learning process in this stage by online using Google Classroom. Regarding the ARCS theory (Attention, Relevance, Confidence, and Satisfaction), the problem at the beginning of the teaching process can make students motivated, interested, and curios in the learning process. The students are given daily life problems online beforehand to increase students' interest in participating in physics classes and make the students more prepared to receive the lesson. In the second phase, the formulation stage, students are asked to make a hypothesis or temporary answer to the problems given by the teacher in the google classroom. The hypothesis can be proposed based on literature review and will be tested at the group discussion stage. The advanced organizers make students to understand the material and combine new information. The critical thinking process can consider a person in gathering relevant information. The next stage is a virtual group discussion using the zoom application. In this stage, the students work in a group to test the previously made hypotheses. The students will be faced with the information. The teachers encourage the students to create and prove hypotheses, problems or facts and find ways to test the hypotheses made. The knowledge construction is carried out by formulating new hypotheses and testing them through investigation activities. The next phase is an analysis, which is carried out with groups online using the zoom application. At this stage, students analyze the data that has been obtained and decide on accepting or rejecting the hypothesis. Analyzing, interpreting, and drawing conclusions

from the data obtained is an activity that aims to improve inference ability and assess conclusions. After conducting the analysis, students and their groups discuss the results by presenting the results that have been obtained. The students in the critical thinking process need students' communication. The last stage is a reflection by online using google classroom. At this stage, the students are expected to evaluate the learning that has been done. Reflection in learning activities is essential for students in reviewing what students have learned. It helps improve the learning system.

Validity of Virtual Classroom Critical Thinking (VC2T)

There are two types of validity investigated for the VC2T, i.e., content validity and construct validity. Content validity is an intervention carried out to meet the needs of its components based on the state of the art of knowledge. Construct validity shows the consistency of all components in the model and connectivity among the components Van den Akker et al., 2013). The validation of the VC2T model has been carried out by 3 (three) validators, who are experts in physics education, which was preceded by a Focus Group Discussion (FGD). The FGD was attended by researchers, three validators, and three practitioners (high school physics teachers). Suggestions and feedback from validators and practitioners were followed up to improve the VC2T Model. After the VC2T model is declared valid, the teaching instruments and CTST assessment instruments are prepared. Teaching instruments consist of the syllabus, lesson plans, teaching materials, and student worksheets. The instruments were validated by 3 (three) validators, the same as the VC2T Model validators. Suggestions and feedback from validators are then followed up to improve instruments to become feasible for implementation.

The assessment of the VC2T model, learning instruments, and CTST use a Likert scale validation sheet consisting of five rating scales, namely 5 = very high validity, 4 = high validity, 3 = medium validity, 2 = low validity, 1 = very low validity (Prayogi et al., 2018). The VC2T model, teaching materials, and CTST are valid (good) if the minimum average validity score is in the valid category. If the model is said less than the valid category, it is necessary to revise. Reliability is calculated using the percentage of agreement and is declared reliable if the percentage of agreement is 75% (Prayogi et al., 2018).

Practically of VC2T Model

The practicality of the VC2T model can be known after evaluating the implementation of the VC2T model in the classroom. The implementation of the VC2T model was observed by 2 observers using an observation sheet with a score range of 1 to 5. Observers were also asked to provide suggestions and input to the VC2T Model supporting tools (teaching materials). The score given by the observers is analyzed by averaging the score given by observers. From the analysis results of the average score obtained, the categories can be shown in Table 2 (Prayogi et al., 2018, p. 47).

Table 2. The VC2T Model Practicality Category

Interval	Category
X > 4.2	Very Good
3.4 < X ≤ 4.2	Good
2.6 < X ≤ 3.4	Adequate
1.8 < X ≤ 2.6	Less
X ≤ 1.8	Poor

The VC2T model is practical if the average score of teaching implementation with the VC2T Model is at least in a good category.

Effectiveness of VC2T Model

The effectiveness of the VC2T model can be evaluated from the improvement of students' critical thinking skills using the CTST instrument is given after the implementation of the VC2T model. The CTST instrument is an essay test. Each item has the highest score of 4 and the lowest score of 0. In this study, aspects of critical thinking skills that have been assessed are Interpretation, Analysis, Evaluation, Inference, and Explanation. The score obtained from CTST before and after teaching is compared by calculating the normalized gain (n-gain) formula as in equation (1) and the categories as shown in Table 3 (Meltzer, as citied in Wahyuni et al., 2020, p. 172).

$$n - gain = \frac{X_m - X_n}{100 - X_n} \quad (1)$$

Remarks:

n-gain = normalized gain

X_m = post-test score

X_n = pre-test score

Table 3. The n-Gain Categories

Interval	Category
n-gain > .7	High
.3 ≤ n-gain ≤ .7	Medium
n-gain < .3	Low

The significance between pre-test and post-test scores was investigated by performing the Paired Sample t-test. It is essential to find out how significant is the impact of the VC2T model implementation. The data analysis technique of the paired sample t-test is carried out using the SPSS version 22 application. The assumption test, i.e., normality test, must be conducted before the paired sample t-test was used. After the paired t-test was carried out, the calculation of the effect size was carried out. Effect size is a method used to measure the effectiveness of a study (Cohen et al., 2007, p. 540), equation (2) is used to calculate the effect size and the categories are shown in Table 4.

$$\text{Effect Size} = \frac{\text{mean of post test score} - \text{mean of pre test score}}{\text{standard deviation}} \quad (2)$$

Table 4. The Effect Size Categories

Interval	Category
0 – 0.20	Weak Effect
0.21 – 0.50	Modest Effect
0.51 – 1.00	Moderate Effect
> 1.00	Strong Effect

The student responses to the model implementation were obtained from Likert-scale questionnaires. The data is analyzed by using quantitative and qualitative descriptive. Analysis of student response questionnaire data uses equation (3).

$$P = \frac{\sum K}{\sum N} \times 100 \quad (3)$$

Remarks:

P : Percentage of students responses

$\sum K$: the number of scores achieved by students

$\sum N$: the highest number of scores achieved by students

The percentage of student responses then converted using categories in Table 5 (Wahyuni et al., 2020, p. 172).

Table 5. The Category of Students Percentage Response

Interval (%)	Category
81 - 100	Very Good
61 - 80	Good
41 - 60	Adequete
21 - 40	Not Good
0 - 20	Bad

The VC2T model is said to be effective if: (1) there is an increase in students' critical thinking skills scores which are statistically significant at alpha .05, (2) the average n-gain at least in the medium category, (3) the minimum effect size is moderate category and (4) student responses at least in the good category.

Data Analysis

A normality test was conducted using the Kolmogorov-Smirnov. The pre-test and post-test normality tests of students' critical thinking skills are shown in Table 6. Meanwhile, the results of the n-gain normality test are shown in Table 7.

Table 6. Normality Test on The Value of Pre-test and Post-test

	Kolmogrov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test	.149	33	.060	.969	33	.465
Post-test	.155	33	.043	.963	33	.305

Table 7. Normality Test on The Value of n-gain

	Kolmogrov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
n-gain	.270	5	.200	.855	5	.212

As shown in Table 6, the significance value for pre-test and post-test data is .465 and .305, respectively. Meanwhile, the significance value for n-gain is .212 (see Table 7). All the significance values are above .05. These results indicate that the pre-test, post-test and n-gain data each come from a normally distributed population. Thus, the next paired t-test can be applied.

Findings / Results

The Virtual Classroom Critical Thinking (VC2T) model is a teaching model to improve students' critical thinking skills, which was developed by adapting the Inquiry and the Blended Learning Model. There are 6 phases in the VC2T model, i.e., (1) problem orientation, (2) formulation, (3) group discussion, (4) analysis, (5) result discussion, and (6) reflection. The explanation of VC2T model phases and the relation to each indicator of critical thinking skill trained are shown in Table 8.

Table 8. Phases of the VC2T Model and Indicators of Critical Thinking Skills

Phase	Teaching Activities	Critical thinking skill indicators
Phase 1: problem orientation (conducted online)	The teacher motivates students by providing videos/pictures/animations, teaching objectives, describing the activity process, and assessing critical thinking skills. In addition, the teacher provides students with problems that exist in daily life.	Interpretation, analysis, inference, explanation
Phase 2: formulation (conducted online)	The teacher asks students to review the literature according to the problem. Then, the teacher asks the students to propose a hypothesis according to the problem based on the literature study results.	Interpretation, explanation
Phase 3: group discussion (conducted online)	The teacher instructs students to plan/design experimental procedures with their respective groups and facilitates students to conduct experiments to test the hypotheses.	Interpretation, inference, analysis, explanation, inference
Phase 4: Analysis (conducted online)	The teacher asks students to analyze the experimental data and decide to accept or reject the hypothesis.	Analysis, inference, interpretation
Phase 5: Result discussion (conducted online)	The teacher asks the group to present the experimental result	Explanation, inference
Phase 6: Reflection (conducted online)	Through LMS, the teacher gives further assignments to students and asks students to reflect on the teaching process.	Interpretation, analysis, evaluation, inference, explanation

The VC2T model has been validated by 3 (three) experts in physics education, and the average results are shown in Table 9.

Table 9. The Result of Validity of VC2T Model

	Aspects of Validation	Average Score	Category
Content Validity	The need for the model development	4.13	High Validity
	The model designed base on state-of-the-art of knowledge	4.00	High Validity
Construct Validity	Consistency and logical arrangement of all components of the model	4.28	High Validity
Average		4.14	High Validity
PA (Percentage of Agreement)		82.73 %	Reliable, PA ≥75 %

Table 9 shows that the average validity score is 4.14 includes content and construct validity, which can be categorized as high validity with reliability of 82.73%, which can be classified as reliable. Meanwhile, the validation results of the VC2T Model supporting teaching instruments are shown in Table 10, and the validation results of the CTST Instrument are shown in Table 11.

Table 10. The Results of The Validation of Supporting Tools of the VC2T Model

Aspects of Validation	Average Score	Category
Syllabus	4.24	High Validity
Lesson Plans	4.30	High Validity
Teaching Materials	4.34	High Validity
Student Worksheets	4.21	High Validity
Average	4.27	High Validity
PA (Percentage of Agreement)	85.44 %	Reliabel, PA ≥75 %

Table 10 shows the validation score of supporting instruments for VC2T Model, which consists of the syllabus, lesson plans, teaching materials, and student worksheets. The obtained average score of 4.27, which can be categorized as high validity. The reliability is 85.44% which can be classified as reliable.

Table 11. Results of Validation of CTST Instruments

Aspects of Validation	Average S core	Category
Construct	4.00	High Validity
Contents	4.00	High Validity
Language	4.00	High Validity
Average	4.00	High Validity
PA (Percentage of Agreement)	80.00 %	Reliabel, PA ≥75 %

Table 11 shows the validity of the CTST instrument, which includes some aspects, i.e., construct, content, and language. The average score of CTST instrument validation is 4.00, which can be classified as high validity. Furthermore, the reliability is 80%, so it can be concluded that the validation is reliable.

At the implementation stage, the practicality of the VC2T model was evaluated by two observers using a checklist. The checklist contains some items about how well the lesson plan is implemented. The average scores of the observations from two observers can be seen in Table 12. The average score for the implementation of the VC2T Model is 4.26. It indicates that overall, the VC2T model has been implemented very well.

Table 12. The Results of The Observations on the Implementation of VC2T Model

Aspects of Observation	Average Score	Category
Problem orientation	4.40	Very Good
Formulation	4.00	Good
Group discussion	4.50	Very Good
Analysis	4.00	Good
Results Discussion	4.00	Good
Reflection	4.25	Very Good
Learning atmosphere	4.25	Very Good
Average	4.26	Very Good

The effectiveness of the VC2T model was evaluated using the CTST instrument given to students before implementation of the VC2T model (pre-test) and after implementation of the VC2T model (post-test). The average pre-test, post-test, and n-gain scores of students' critical thinking skills can be seen in Table 13.

Table 13. Mean of pre-test, post-test, and n-gain

Aspects of Calculation	Average Score
Pre-test	42.7
Post-test	64.34
n-gain	.38

Table 13 shows that the post-test score of students' critical thinking skills is greater than the pre-test score; it shows an increase in students' critical thinking skills scores after applying the VC2T teaching model, with the level of

improvement in the medium category. Then, paired t-test was performed using SPSS version 22, and the results are shown in Table 14.

Table 14. The Result of Paired t-test

	N	Mean	S	df	t	Sig. (p)
Pre-test-Post-test	33	-14.24	2.13	32	-38.56	.000

*p = .05

Table 14 shows the results of the paired t-test of students' critical thinking skills with sig. .000, which means that there is a significant difference between the pre-test score and the post-test score. The t-value is negative because the post-test score is greater than the pre-test score. In other words, there is an increase in students' critical thinking skills scores after teaching with the VC2T Model. The result of the effect size test to know the effectiveness of the VC2T model is 6.93 with a strong effect category.

At the end of the lesson, students are asked to fill out a Student Response Questionnaire, which aims to find out the students' responses to the teaching of the VC2T model. It is needed to find out student responses to the VC2T implementation and to investigate the advantages and disadvantages of the VC2T model from the students' point of view. The student's response is shown in Table 15. The average score of students' responses is 87.59%, which can be interpreted as very good response.

Table 15. The Results of Student Response Questionnaire Assessment

No.	Statement	Response	
		Percentage (%)	Category
1.	The activities in the VC2T model are fun	92.46	Very Good
2.	The novelty of teaching material and activities of the VC2T model is good	92.46	Very Good
3.	Teaching materials can be easily understood	79.34	Good
4.	The learning activities that have been followed are exciting and fun	87.10	Very Good
5.	After learning activities using the VC2T model, critical thinking skills are further improved	83.90	Very Good
6.	I am very happy if other subjects or materials are taught using the VC2T model again	90.30	Very Good
Average		87.59	Very Good

Discussion

Based on the data analysis and the findings, the following discussion was carried out on the research results. Table 9 shows that the validation results of the VC2T Model developed are declared high validity by experts. The average score of the validity of the VC2T model is 4.14, which is categorized as high validity; the reliability percentage is 82.73%, and there are slight revisions that need to be done by the researcher. In this study, the main goal of content validation is to ensure the need for model development and the state of the art of knowledge to design the model are appropriate. The need for model development is the main foundation in developing teaching models. The average content validity score on the need aspect is 4.13 with a high validity category, and on the state of the art of knowledge aspect, it is 4.00 with a high validity category. Construct validity is focused on the theoretical review and empirical review that supports the model. The result of the validation on the state-of-the-art knowledge aspect is 4.28, with a high validity category. Prayogi et al. (2018) argue that critical thinking has its uniqueness, namely the number of different theories with different views, thus making the measurement and assessment of critical thinking difficult. In this study, simplification was carried out by developing a test instrument using 5 indicators of critical thinking skills adopted from Facione (2015): interpretation, analysis, evaluation, inference, and explanation.

Table 10 results from the validation process of the teaching instruments used to implement the VC2T model: syllabus, lesson plans, student teaching material, and student activity sheet. The average score for the syllabus, lesson plan, learning material, and students' worksheet is 4.24, 4.30, 4.34, and 4.21, respectively, which can be highly valid. Overall, the teaching instruments can be classified as highly valid, with an average score of 4.27 and reliability of 85.44%. Table 11 shows the average score of the critical thinking skills tests instrument by assessing three aspects: the construct, content, and language aspects. All aspects can be categorized as highly valid. It shows that the teaching materials and critical thinking skills test instruments are highly valid and can be used in the implementation stage.

At the implementation stage, the model's practicality was measured by two observers with seven aspects observed, namely orientation, formulation, group discussion, analysis, results discussion, reflection, and learning atmosphere, getting an average of 4.26 with a very good category, as shown in Table 12. According to the observation, all aspects can be classified as very good. The model can be implemented well due to the complete teaching materials used, especially student teaching materials and student activity sheets. Well-designed teaching materials can provide information that

helps students more effectively achieve teaching goals (Prayogi et al., 2018). In addition, well-designed teaching materials can serve as communication tools, teaching planning tools, teaching plans for students, learning resources, and teaching evaluation tools (Prayogi et al., 2018).

Table 13 shows that the post-test score of students' critical thinking skills is greater than the pre-test score, with improvement in the medium category. It shows that there is an increase from pre-test to post-test due to implementing the VC2T Model. It indicates that the VC2T model can train students' critical thinking skills, just like the research results from Fitarahmawati and Suhartini (2021), distance learning can improve students' critical thinking skills during the covid-19 pandemic. Paired t-test was used to test the increased post-test scores statistically significantly by SPSS Version 22 software. Before the paired t-test was carried out, the normality assumption was first tested for the increase in pre-test and post-test scores of students' critical thinking skills by the Kolmogorov-Smirnov test. Table 6 and Table 7 show that the normality test results of students' critical thinking skills for pre-test, post-test, and n-gain scores are .465; .305, and .212, respectively. It means that the sample data comes from a normally distributed population. In addition, in Table 14, t is negative, i.e., -38.56, which indicates that the post-test score is greater than the pre-test score. In other words, statistically, at the significance level of .05, there was an increase in the score of students' critical thinking skills after being applied to teaching using the VC2T model. It shows that the phases in the VC2T model can train critical thinking skills indicators. The result is aligned with Changwong et al. (2018), which says that critical thinking requires students to be skilled and active in synthesizing, analyzing, applying, and evaluating information to reach an answer or a conclusion. Those activities are included in the VC2T Model.

At the end of the lesson, students were asked to fill out a response questionnaire that aims to find out students' responses to the teaching of the VC2T model in Table 15. The student responses showed that the average percentage obtained was 87.59% in the very good category. It proves that most students are happy with teaching with the VC2T model.

Although teaching with the VC2T model can improve students' critical thinking skills, there are still weaknesses. Some students are still not ready for online learning because they do not have supporting devices and insufficient internet access.

This study shows that the VC2T model has been found to be valid, effective and practical to improve the critical thinking skills of high school students in physics learning. Critical thinking skills include five indicators: interpretation, analysis, evaluation, inference, and explanation. The findings of this study indicate that the VC2T model can improve students' critical thinking skills and be used as a consideration for future research related to students' critical thinking skills.

Conclusion

In this study, we have developed VC2T model in an online physics class. The developed VC2T model is classified as valid, practice, and effective in improving the critical thinking skills of high school students. The results showed that (1) the VC2T model was valid, which was indicated by the average score of the model's validity of 4.14 with a high validity category, the validity of supporting tools for the VC2T model was declared high validity with an average of 4.27, and CTST was declared high validity with an average of 4.00; (2) The VC2T model is practical, indicated by an average score of teaching implementation 4.26 (in the very good category); and (3) the VC2T model is effective, it is shown by the increase in Critical Thinking Skills which is statistically significant at significance (α) of .05, the average n-gain of .38 with medium gain category, the effect size of 6.93 with strong effect category it is shown that the effectiveness of VC2T model is strong, and the average student response results during teaching with a percentage of 87.59% in the very good category. Thus, the VC2T model can be used as an online teaching model in training high school students' critical thinking skills.

Recommendations

Based on the research result, we propose the VC2T teaching model that can be implemented as an alternative teaching model during the pandemic era. In addition, this VC2T teaching model can also help students improve critical thinking skills needed in the 21st century and the industrial revolution 4.0. However, further research is still required to investigate the implementation of the VC2T teaching model in a more significant number of samples. It would evaluate the reliability of the VC2T teaching model.

Limitations

There are some limitations, i.e., the number of participants in this study is relatively small (only 33 students), using google classroom and zoom application, the teaching materials such as student textbook, student worksheets, lesson plans, syllabus, and CTST instrument, and application of models only cover the topics of heat and heat transfer. In addition, the number of samples in this study is limited, namely only 33 students who are in class XI-IPA at SMA Dr. Soetomo Surabaya.

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Authorship Contribution Statement

Lestari: Concept and design, data acquisition, data analysis/interpretation, drafting manuscript and editing. Supardi: Reviewing, technical or material support, supervision. Jatmiko: Editing/reviewing, critical revision of manuscript, technical or material support, supervision, final approval.

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Appendix

OBSERVATION SHEET OF IMPLEMENTATION TEACHING OF
VIRTUAL CLASSROOM CRITICAL THINKING (VC2T) MODEL

Observer: ………………………………………………………………………………

Profession: …………………………………………………………………………....

Purpose:

To find out the practicality of learning by using the Virtual Classroom Critical Thinking Model (VC2T).

Instructions:

1. Please put a check mark (√) in the rating scale column that matches your opinion with the following criteria:
   1 = Not Executed
   2 = Poorly Implemented
   3 = Executed Fairly Well
   4 = Well Executed
   5 = Very Well Executed
2. Your assistance in filling out this sheet is very useful in developing the Virtual Classroom Critical Thinking (VC2T) model. We thank you for your willingness and assistance.

The implementation teaching sheet is reviewed from several aspects of the assessment as follows:

Phase	Observed Activity	Criteria				
		1	2	3	4	5
1.	**Problem orientation (conducted online by google classroom)**					
	a. Say hello by google classroom with the Stream feature					
	b. Delivering teaching objectives and teaching materials that will be studied online by Google Classroom application using the stream feature					
	c. Motivate students by google classroom application with the stream feature.					
	d. Providing problems to students by the google classroom application.					
	e. Asking students to formulate a problem					
2.	**Formulation (conducted online by google classroom)**					
	a. Asking the students to review the literature or sources of information related to the problems					
	b. Asking the students in each group to propose a hypothesis based on the results of the literature study					
3.	**Group discussion (conducted online by Zoom)**					
	a. Asking students to watch the practicum video to test the hypothesis					
	b. Asking the students to discuss with their groups by breakout rooms on zoom					
4.	**Analysis (conducted online by Zoom)**					
	a. Asking the students to analyze experimental data to conclude that the hypothesis can be accepted or rejected					
5.	**Result discussion (conducted online by Zoom)**					
	a. Guiding the students in groups to present or communicate the results of discussions in front of the class					
6.	**Reflection (conducted online by Google Classroom)**					
	a. Giving the students the assignments					
	b. Open online class discussions and provide feedback to students					
	Learning atmosphere					
	The suitability of teaching and learning activities with teaching objectives					
	Enthusiastic the teacher					
	Enthusiastic the students					
	Time Allocation					

Surabaya, ………………2021

Observer