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Effectiveness of Clarity Learning Model to Improve Students' Advanced Clarification Critical Thinking Ability in Physics Courses

Sigit Dwi Saputro[1,2*], Tukiran[1], Zainul Arifin Imam Supardi [1]

[1]Universitas Negeri Surabaya

[2]Universitas Trunojoyo Madura

Abstract

Clarity Learning Model (CLM) is an innovative model developed based on the excellence of IBL that is tailored to the needs of advanced clarification critical thinking ability through the implementation of distance learning due to the Covid 19 pandemic. This study aims to test the effectiveness of CLM that has qualified valid. The type of research used is a pre-test and post-test group design. The sample in the study consisted of two classes. Class 1 consisted of 24 students, while class 2 consisted of 18 students. Effectiveness is obtained through pre-test and post-test results whose N-gain calculations and N-Gain Average Test difference are then analyzed using Mann Whitney Test. The results in the study showed that CLM is effective in improving the critical ability of advanced clarification in physics courses. These research suggestions are to conduct trials on a broader scale and optimize LMS as a provision for students' initial skills.

Keywords: Advanced Clarification Critical Thinking ability, Clarity Learning Model, Physics Courses.

Introduction

The demand of every graduate in college is expected to be able to work professionally (Kementerian Pendidikan dan Kebudayaan, 2012). Professional work requires critical thinking skills (Bassham & Wallace, 2013; P. Facione & Gitten, 2016). We test the small molecule flexible ligand docking program Glide on a set of 19 non-α-helical peptides and systematically improve pose prediction accuracy by enhancing Glide sampling for flexible polypeptides. In addition, scoring of the poses was improved by post-processing with physics-based implicit solvent MM- GBSA calculations. Using the best RMSD among the top 10 scoring poses as a metric, the success rate (RMSD ≤ 2.0 Å for the interface backbone atoms. This ability is vital because someone who uses critical thinking skills will optimize his intellectual capacity to make the best decision (Davies, 2015; Ennis, 2015).

There are many opinions on the concept of critical thinking. Ennis (1985) argued that critical thinking is the skill for decision-making for solving problems based on rational, analytical skills, thus producing confident findings. Facione (2000) stated that critical thinking skills are cognitive skills, including interpretation, analysis, evaluation, inference, explanation, and self-regulation. Critical thinking is problem-solving in achieving the best solution (McPeck, 2017: 11). Critical thinking is purposeful thinking and aims to solve problems (Stephen Johnson Harvey Siegel, 2010; Halpern, 2003; Yıldırım & Uzun 2021). So far, the inquiry-based learning (IBL) model has been implemented in physics courses. The learning situation used consists of five phases: problem presentation, problem verification, hypothesis, data collection and explanation, and reflection (Arend, 2012), (Joyce, B., & Weil, 2000). The inquiry learning model was chosen because one of the appropriate science learning models for twenty-first-century learning (Dewi, 2020), (Scott, 2015). The main reason for selecting the inquiry model is because apart from being able to train critical thinking (Arend, 2012), (Herawati et al., 2020), (Rahmi et al., 2019). On the other hand, this model learning also follows the objectives of achieving introductory physics courses, namely the formation of concepts (Arend, 2008, Duke, 1990).

However, based on the results of previous research in a physics course, advanced clarification critical thinking ability is still weak. Many 60 students were studied using the instrument used in a test form adapted from previous research. Meanwhile, critical thinking levels are categorized as critical, quite critical, less critical, and very less critical (Seruni et al., 2020). As many as 42 or 72% of students are included in the very less critical level. Students are only able at the less critical

Corresponding Author e-mail: sigit.dikti@gmail.com

ORCID Number: 0000-0002-5924-5518

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level as much as 18 (18%). Even most students are at the very less critical level as much as 42 (72%). Reinforced the average value of the class only obtained a score of 32, which is included in the very less critical category.

The low of this ability is caused by the students' inability to connect the concepts they possessed with the problem description that needs to be solved. These results follow previous research on chemistry subjects, and students cannot decrypt the different questions from the examples given (Herunata et al., 2020), (Sumarni & Kadarwati, 2020) attention to the local culture especially that is closely related to the scientific concepts needs to be strongly emphasized. Due to those two aspects i.e. creative and critical thinking as well as attention to local culture, the ethno-STEM project-based learning for high school students has been implemented and its impact on students' critical and creative thinking skills has been investigated. This study involved 230 students from seven high schools in Central Java, Indonesia. The data collection was carried out through a set of instruments to reveal the students' critical and creative thinking skills. The instruments were declared as valid based on the experts' judgment and showed an Alpha Cronbach score of 0.79 before use. The results showed that the ethno-STEM project-based learning was able to improve the average critical and creative thinking skills of students in all indicators varying from low to medium categories. The improvement of students' critical thinking skills was observed by the achievement of the N-gain score, i.e. 52 students (22.6%. Likewise, in research in optical physics courses, students cannot analyze the concepts used to determine the correct position of several choices that have been presented in an image to produce a predetermined image (Pradana et al., 2017).

The next problem is that students cannot use the concept of reasoning to answer open-ended questions. Students can only answer the mathematical equations without any rational argumentation. Likewise, previous research showed that students did not explain the right reasons for answering questions (Sumarni & Kadarwati, 2020). The interview result with students also indicated that they could not make excuses in answering questions (Herunata et al., 2020), (Pradana et al., 2017).

Learning Model

The learning model is one way for educators to achieve specific learning goals (Arend, 2008:178). Likewise, Aunurahman (2009:140) learning model aims to create learning conditions that make students active and fun to obtain optimal learning outcomes and achievements. Specifically, the learning model aims to help students master information, generate ideas, have skills, build ways of thinking, and the meaning of learning through their learning styles and arranged in careful and structured planning (Joyce et al., 2009).

The learning model preparation needs to pay attention to diversity in the classroom to achieve the expected goals, such as cognitive development, intelligence, and learning styles (Arend, 2008). In a psychological study on the learning model effectiveness, the development of learning models needs to pay attention to differences in academic ability levels (Slavin, 2011). This opinion is reinforced Aunurahman (2009); the learning model development needs to pay attention to diversity in personality characteristics, habits, student learning modalities, facility factors such as class conditions, material characteristics, and learning environment.

Ideal learning principles to help students' abilities. Each educator or model designer may analyze and select elements under the expected goals (Duke, 1990). The model development process needs to be explored on the primary rationalization of the learning model development (Arend, 2012). The final product of the learning model is in the form of a syntax consisting of several phases in detail by researchers to make it easier for readers to implement the developed model (Joyce, B., & Weil, 2000). The results of the phase formation in the learning model syntax need to be tested for validity, practicality, and effectiveness (Plom & Nieveen, 2013)

The clarity Learning Model (CLM) was made to improve the advanced clarification critical thinking ability skill. The process of learning model forming requires rationalization to achieve the goals that have been set. The final result of model development is a syntax consisting of several learning phases; before testing the learning model effectiveness, the validity will be tested.

CLM Overview

CLM was developed to increase the advanced clarification critical thinking ability. The development of this model was formed based on an analysis of the advantages of IBL, which took into account the problems and suggestions of the review results of various studies. Before learning activity, CLM optimizes learning management system (LMS) in asynchronous activities, which include the provision of material, simulation videos, assignments, which are expected to facilitate preparation for learning at a different pace for each student. Synchronous activity this learning model consists of five phases, including problem orientation, investigation, reasoning, clarification, evaluation, and reflection.

Phase 1 is problem orientation. This phase is adapted from IBL, which contains a given problem situation. The activities done by students are focused on the facts presented by the lecturer, and they provide arguments according to the knowledge from experience owned by each student. The presentation of this exact problem aims to focus on and increase student motivation in learning (Moreno, 2010; Slavin, 2011). The given issues can increase the curiosity to find results as accurately as possible (Facione, 1990). Even the provision

of problems can stimulate students to develop their critical thinking skills (Diani et al., 2020; Herawati et al., 2020; Sumarni & Kadarwati, 2020). The effect size fell in the high category with 1.19. The highest N-Gain was for the indicator of elementary clarification (N-gain = 0.81 The provision of textbooks, phet applications, and practical simulation videos through LMS before the meeting aims to make learning more effective.

Phase 2 is investigation. This phase is adapted from IBL, which contains problem identification, hypotheses, data collection, and presentation. The activities done by students are focused on the facts presented by the lecturer, and they give arguments according to the knowledge from experience owned by each student. The presentation of this exact problem focuses on and increases student motivation in learning (Moreno, 2010; Slavin, 2011). The given issues can increase the curiosity to find results as accurately as possible (Facione, 1990). Even the provision of problems can stimulate students to develop critical thinking skills (Diani et al., 2020; Herawati et al., 2020; Sumarni & Kadarwati, 2020). Students perform simulations individually before the meeting, which is intended to be practical learning activities.

Phase 3 is reasoning. This phase is a form of the problem solution on answering questions by connecting relevant concepts and unfamiliarity in using reason to make arguments. The lecturer's activity is to appoint students to analyze sample questions where the answer keys are available. This activity is also an implementation of guided training activities. The lecturers allow students to ask questions if a concept or discussion has not been understood. Critical thinking is rational thinking based on evidence (Ennis, 2016; P. Facione & Gitten, 2016; Halpern, 2014). Task assignments can optimize a person to focus on choosing the appropriate material to complete the goals that have been given (Roberson & Franchini, 2014), (Wang et al., 2019). The design of the alignment task has proven that it can improve critical thinking skills (Saputro et al., 2020).

Phase 4 is clarification and evaluation. This phase is a form of strengthening rational abilities with guided training activities. Lecturer activities are lecturers giving quizzes and asking students to complete the examination in 5-10 minutes, then appointing students to convey the work results. The lecturers evaluate the work results and provide opportunities for students to ask questions that students do not understand. Through guided practice activities such as quizzes and clarifications, they can improve their critical thinking skills (Ennis, 2016; Halpern, 2014). Thus, the lack of guided practice in inquiry learning (Duran & Dökme, 2016; Putra et al., 2018) can be adequately handled. This activity implements previous research advice to facilitate the exercises to improve critical thinking skills (Diani et al., 2020), (Herunata et al., 2020.

Phase 5 isreflection. Thisphaseisadaptedfromthe IBLmodel. The lecturer reflects on all phases, shows the discussion objectives, and asks students to answer the material content of each grid together. Before closing, the lecturer asked students to summarize the material in a mind map collected through LMS. This phase aims to improve learning meaningfulness through organizing information structures (Moreno, 2010). The assignment process of making mand map charts or advanced organizers can enhance critical thinking skills and learning achievements (Prayogi & Verawati, 2020; Saputro et al., 2014).

Research Question

Ennis develops critical thinking components, consisting of basic clarification, basic support, inference, advanced clarification, and facilitative abilities. Based on the analysis of advanced clarification critical thinking ability, this ability is very suitable in higher education. The results of previous studies and relevant research studies show the low advanced clarification critical thinking ability. Rationalization of the CLM syntax development based on research problems and suggestions is considered to improve students' advanced clarification critical thinking ability. The main objective of this research was to determine the improvement of students' advanced clarification critical thinking ability after being given the CLM model intervention. A detailed description of this research's purpose is investigated by making research questions. 1) How is the average class's improved advanced clarification critical thinking ability due to CLM intervention? 2). How is the improvement profile of each indicator of advanced clarification critical thinking ability due to CLM intervention? 3) Will the increase in advanced clarification critical thinking ability have the same impact from the CLM intervention? And 4) Will the increase in each indicator of advanced clarification critical thinking ability have the same impact on the consequences of providing CLM interventions?.

METHOD

Research Design

This research design uses a pre-test post-test group design. The stages of this research are summarized as shown in Figure 2.

The first stage validity of design CLM and test instrument advanced clarification of critical thinking ability by three experts in science learning. The method in this stage used

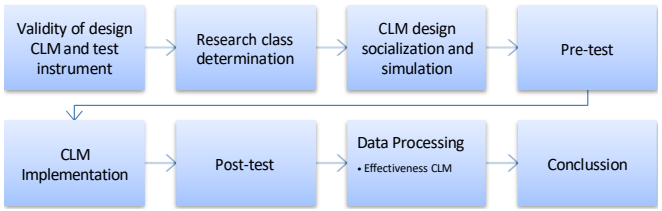

Fig. 2: Stages of research implementation

Focus Group Discussion (FGD). Validators had been given a draft of the model development and the test instrument one week before the FGD. The CLM was compiled in a model book with an academic text. At the same time, the test was based on seven indicators of critical thinking skills for advanced clarification developed by Ennis. Both the CLM design and the test instrument are measured for content validity and construct validity, as well as the reliability level.

CLM design validity and reliability. Content validation assessment by three validators obtained an average score of 3.85. The results of this score are included in the very valid category. While the moderate construct validity of 3.87 is included in the very valid category. The reliability results of the CLM design obtained an index value of 0.96 can be categorized as reliable. Thus, the CLM Design is feasible to be used as a learning instructional.

The test instruments validity and reliability of advanced clarification critical thinking ability. The total average content validity results obtained by 3.77 can be categorized as very valid. The results of the moderate construct validity obtained at 3.73 can be classified as very valid. The results of the instrument test reliability got an index value of 0.88, which can be categorized as reliable. Thus, the instrument test is feasible to measure the advanced clarification critical thinking ability.

The second stage was determining the research class. The research class was determined based on the daily grades for physics courses to see that the two types are equal. The two classes' equality level was carried out through a compare means test.

The third stage was socialization and simulation of CLM design. At this stage, the 1st and the 2nd experimental classes were explained each step of CLM. The main objective at this stage is to make the learning process to be following the CLM phase and get used to using distance learning technology. The technologies used in this learning were Phet simulation and the trial of Edmodo's learning management system (LMS) feature.

The fourth stage was the pre-test. This activity was carried out before the CLM treatment was given. The technical implementation was that the lecturer and the students were connected in the video conference application, zoom. The lecturer displayed questions, and the students directly answered them in their notebooks by including their identity. The test consisted of essay questions, consisting of 7 queries. Each problem represents one indicator of advanced clarification critical thinking skills developed by Ennis. Every student had one hundred minutes given to finish the task.

The fifth stage was implementing the CLM model, consisting of five phases. Learning orientation, investigation, reasoning, clarification and evaluation, and ref lection. The implementation of CLM learning was carried out synchronously in which the lecturer and students were connected online using the Zoom Meeting application.

Table 1: Distribution of materials and advanced clarification critical thinking ability skills in each meeting

Meeting	*Material Subject*	*Indicators of advanced clarification critical thinking skills*
First	Basic concepts of "Work."	Judge definitions using appropriate criteria.
Second		Handle equivocation appropriately.
Third	Relationship of Work and Energy	Attribute and judge unstated assumptions.
		Think suppositionally.
Fourth	Mechanical Energy	Deal with fallacy labels.
		Be aware of, and check the quality of their thinking (metacognition).
		Proceed in an orderly and reasonable manner appropriate to the situation

Meanwhile, sharing materials and assignments submission used the Edmodo Learning Management System (LMS). During the class, the students would be trained in problem-solving of seven indicators of critical thinking skills on "work and energy," as shown in table 1.

The sixth stage was post-test. Students answered a critical thinking skills test of seven questions. Each question represents an indicator of advanced clarification essential skills of thinking.

The seventh stage was data processing. It was done to test the effectiveness of CLM in improving the critical thinking skills of advanced clarification and the profile of students' advanced clarification critical thinking improvement.

The last stage was making conclusions and suggestions for improving the CLM model. The findings were made based on the results of statistical tests, while the recommendations for the model improvement were obtained from the students' advanced clarification critical thinking improvement profile. The profile analysis would be described quantitatively to determine the achievement target of each student's critical thinking stages.

Population and Sample

The population in this study was informatics education students who took physics courses. There are 90 students divided into four classes. The research sample was taken by 42 students divided into two experimental courses. Experimental class 1 consisted of 24 students, while the second experimental class consisted of 18 students. Both experimental classes have the same level of ability based on the evaluation results of previous courses.

Data Collection Tools

The instrument validity of the Clarity Learning Model is in the form of a validation sheet consisting of content and construct validity assessments. Content validity consists of

16 questions with details: aspects of Clarity Learning Model development needs 4, state of the art knowledge aspects 4, and component aspects of learning models 8. Construct validity consists of 18 questions with details: aspects of overview Clarity Learning Model are 3, the aspects of the suitability of theoretical and empirical support are 5, the implementation and planning aspects of the Clarity Learning Model are 4, and the learning environment aspects of the Clarity Learning model are 2.

Instrument validity tests critical thinking skills, advanced clarification content, and construct validity. Content validity consists of 6 questions with details: aspects of clarity of purpose of questions are 3, and aspects of the accuracy of learning materials are 3, Construct validity consisting of 5 questions with details: aspects of ambiguity are 2, and language aspects in question sentences are 3.

The expert with a rating scale assessed content and construct validity. The expert gave a score of 1 to 4. The expert was allowed to provide input on every aspect to improve the quality of the learning model and test instrument.

Data Collection And analysis

The effectiveness was measured based on the pre-test and post-test results by measuring N- gain and the N-gain difference test. The results of the N-gain measurement are categorized in Table 2. The CLM model is effective if it can achieve a minimum N-gain in the medium category.

The N gain difference test was used to measure the difference in advanced clarification critical thinking skills in experimental class 1 and experimental class 2. The N-gain difference test measures differences in advanced clarification critical thinking skills on the average of all indicators and each indicator in both experimental classes. The measurement of the difference in N-gain used the Independent T-test. The CLM model can be categorized as effective if there is no difference between the two class groups. Before the T-test, the data were tested for normality and homogeneity of experimental class 1 and experimental class 2 (Siregar, 2015: 157-163).

The results of the normality test showed that experimental class 1 had a significance of 0.00 while experimental class 2 had a significance of 0.00. Thus, both classes are included in the non-normal distribution. The results of the homogeneity test obtained a significant value of 0.02. Thus, the data of the two classes are included in the non-homogeneous. Therefore, to test the average difference of all advanced clarification critical thinking indicators, it used the Mann-Whitney.

Table 2: Normalized Gain Criteria for Each Indicator

N-Gain Score	*Normalized Gain Criteria*
0.70 < N-gain	High
0.30 ≤ N-gain ≤ 0.70	Medium
N-gain < 0.30	Low

Source: (Hake, 1999)

FINDINGS

Improved Advanced Clarification Critical Thinking Ability on The Average Class

The improvement of advanced clarification critical thinking ability on the average class was identified through the results of the pre-test before learning, the implementation of CLM, ended with the calculation of post-test scores. The pre-test and post-test calculation results obtained from the N-gain score of advanced clarification critical thinking skills in the leading physics courses of work and energy using CLM in experimental class 1 and experimental class 2 are shown in table 3.

Based on table 3, it is known that in experimental class 1, a total of 24 students had an average pre-test score of 3.2, while the post-test with a score of 28.0 obtained N-gain 0.78, which is included in the high category. In comparison, the experimental class 2 with a total of 18 students obtained an average pre-test score of 3.2, while the post-test with a score of 25.5 obtained N-gain 0.70, which is included in the high category.

Improvement of Each Indicator Of Advanced Clarification Critical Thinking Ability

The results of the pre-test and post-test calculations were calculated for each indicator. The average value of each indicator in the pre-test and post-test was measured using N-gain. Upgrade details on each indicator for the two classes are summarized in table 4.

The indicators on the components show diverse results as the data in table 4. Using appropriate criteria, the indicator

Table 3.: N-gain analysis of experiment 1 and experiment 2

Class	*N*	*Pre-test Mean*	*Post-test Mean*	*N-gain score*	*Category*
Experiment 1	24	3.2	28.0	0.78	high
Experiment 2	18	3.2	25.5	0.70	high

Table 4: N-gain analysis on each indicator of advanced clarification critical thinking skills

No.	*Indicators of Advanced Clarification Critical Thinking Ability*	*N-gain*	*Category*
	Judge definitions using appropriate criteria.	0.76	High
	Handle equivocation appropriately.	0.67	Medium
	Attribute and judge unstated assumptions.	0.72	High
	Think suppositionally.	0.77	High
	Deal with fallacy labels.	0.77	High
	Be aware of, and check the quality of, their own thinking (metacognition).	0.72	High
	Proceed in an orderly and reasonable manner appropriate to the situation.	0.71	High

of judge definitions obtained an N-gain score of 0.76 and is included in the high category. Handle equivocation appropriately got an N-gain score of 0.67, which is included in the medium category. Attribute and judge unstated assumptions got N-gain score of 0.72, which is included in the high category. Think suppositionally obtained a score of 0.77 included in the high category. Deal with fallacy labels obtained a score of 0.77, including in the high category. Being aware of and checking the quality of their own thinking (metacognition) got a score of 0.72, which is included in the high category. Proceed in an orderly and reasonable manner appropriate to the situation obtained a score of 0.71 and is included in the high category.

The Impact of CLM on Enhancement of Advanced clarification critical thinking ability

The next stage was the difference test in advanced clarification critical thinking ability improvement for the average of all indicators. Based on the pre-requisite test, the experimental class 1 and experiment 2 are normally distributed and homogeneous thus the independent parametric T test was used. Details of the test results are mentioned in table 5.

The Mann Whitney test calculation results obtained a significance of 0.49, so it can be concluded that there is no difference in N-gain of the experimental class 1 and experimental class 2. Thus, CLM provides the same effect of increasing advanced clarification critical thinking skills for both classes.

Table 5.: Test the difference in the improvement of advanced clarification critical thinking ability in the two experimental classes

Data	*Sig*	*Decision*	*Conclusion*
Experiment 1 and Experiment 2	0.49	Ho is accepted	There's no difference

Table 6: Test the difference in the improvement of each advanced clarification critical thinking ability indicator in the two experimental classes

Data	*Sig*	*Decision*	*Conclusion*
Judge definitions, using appropriate criteria.	0.92	Ho is accepted	There is no difference.
Handle equivocation appropriately.	0.96	Ho is accepted	There is no difference.
Attribute and judge unstated assumptions.	0.41	Ho is accepted	There is no difference.
Think suppositionally.	0.59	Ho is accepted	There is no difference.
Deal with fallacy labels.	0.54	Ho is accepted	There is no difference.
Be aware of, and check the quality of, their own thinking (metacognition).	0.81	Ho is accepted	There is no difference.
Proceed in an orderly and reasonable manner appropriate to the situation.	0.88	Ho is accepted	There is no difference.

The Impact of CLM on the Improvement of Each Indicator of Advanced clarification critical thinking ability

Meanwhile, the difference in the improvement of advanced clarification critical thinking skills for each indicator does not meet the pre-requisites for the analysis test, so the Kruskal Wallis non-parametric test was used. The details of the test results are mentioned in table 6.

Based on Table 6, all indicators have a significance value of more than 0.05. It means that CLM provides the same increasing effect for all indicators tested. Thus, CLM gives the same advanced clarification critical thinking improvement effect for each indicator advanced clarification critical thinking ability.

DISCUSSION

The learning model can be said to be effective if it is able to achieve the specified goals (Akhdinirwanto et al., 2020; Honebein & Honebein, 2015). CLM is able to achieve the goal of improving advanced clarification critical thinking skills. This model learning is inseparable from the CLM design, which was developed based on the excellence of the inquiry model by considering distance learning. The indicators of the CLM model can be categorized as effective, obtained from the calculation of the minimum N-gain in the medium category (Hake, 1999) and the N-gain increase difference test obtained that Ho is accepted or CLM provides the same increasing effect for both experimental classes.

Based on the calculation of the pre-test and post-test data, N-gain data and the difference in N-gain for the experimental class 1 and experimental class 2 have been obtained and are included in the high category. Likewise, the seven indicators of advanced clarification critical thinking skills include six indicators in the high category and one indicator in the high category. N-gain in research data can be effective if it is included in the medium category (Hake, 1999). Thus based on the N-gain criteria, CLM can be categorized as an effective learning model.

The results of the N-gain difference test for the two classes concluded that there was no difference in the increase in the advanced clarification critical thinking skills for the two classes. Supported by the data that CLM gives the same effect for all indicators of advanced clarification critical thinking skills. Thus, the provision of the CLM model gives the same effect of advanced clarification critical thinking skills improvement for both experimental classes.

Strong evidence of the effectiveness of this improvement lies on how to answer questions before and after the learning

intervention with CLM. At the beginning of the pre-test, it was identified into two categories, namely wrong in making decisions or right in making decisions but unable to argue. The sample evidence of answers at the time of the pre-test is shown in table 7.

In the category in wrong answer, students have not mastered the concept of work. The main factor in determining a person's critical thinking ability is determined by the strength of the knowledge used to build arguments in making decision (Saiz & Rivas, 2011). This problem confirms the results of the learning experiment research with the subject of class 10 Pakistani students in chemistry learning with a problem based learning model and pre-test post-test control group design which concluded that the low critical thinking skills is due to the lack of students' initial knowledge (Awan et al., 2017). critical thinking skills and achievement of 10th grade students in chemistry. In this experimental study the students of two intact groups of Govt. high school 79 SB Sargodha, were selected as experimental (N=35A large-scale survey conducted in Sweden with 76 students in various cities concluded that a person's critical thinking skills is influenced by the student's prior knowledge. Research survey in Indonesia obtained the result that the factor causing the low ability to think critically on advanced clarification is the initial knowledge possessed by students (Herunata et al., 2020; Pradana et al., 2017).

The next category is right in making decision but cannot argue correctly shows the weak ability of advanced clarification. This ability is identic with complex thinking and the ability to make decisions based on a review of the situation (Ennis, 2015). Other opinions of critical thinking are possessed by someone if they have been able to connect knowledge with problems in making the right decision (Halpern, 2014). In addition, ability at this level requires precise interpretation, analysis, evaluation and inference (Hughes et al., 2015).

While at the end of the learning of the post test, based on the evaluation of the results of the answers to the questions, students have had arguments every time they answer questions but not all students prove it with mathematical calculation. Table 8 is an example of excerpts from the results of the students' post-test.

This difference in the results of the answers resulted in differences in the level of improvement in critical thinking skills for advanced clarification. With the improvement of critical thinking skills for advanced clarification in the high category, most students have reached point 2. They can make appropriate arguments, use mathematical abilities and draw a conclusion. While in the medium category, students have argued but have not provided mathematical proof and made a conclusion.

Therefore, CLM has improved previous research with Ethno-Stem Project-Based Learning intervention in chemistry subjects. The results of the majority of students do not make rationalizations in answering questions

Table 7: Examples of student questions and answers during pre-test

No.	*Question*	*Answer*	*Information*
	Object A and B which have different mass of 5 kg and 10 kg get the same thrust of 110 N on a slippery base along 3 meters. In your opinion, the work of the two objects is the same or different? Explain!	This must be different because of the difference in both objects mass.	Wrong decision
	Two nails with a mass of 10 g are dropped at a certain height on a Styrofoam and plasticine base. Both nails hit the Styrofoam and plasticine base at the same velocity, 5x10-2 m/s. If the ratio of the average upward force of Styrofoam to nails and plasticine to nails is 1:2, then according to you, the nail that goes deeper is the nail on the Styrofoam base or the nail on the plasticine base?	Styrofoam, because it's softer	Right in making decision but can't argue correctly

Table 8: Examples of questions and students' answers during the post test

No.	*Question*	*Answer*	*Information*
	Object A and B which have different mass of 5 kg and 10 kg get the same thrust of 110 N on a slippery base along 3 meters. In your opinion, the work of the two objects is the same or different? Explain!	The work of the thrust will be the same, this is because both the force and displacement variables for both objects are the same. As the equation .	Able to argue but not show the value of the work.
		The work of the thrust will be the same, this is because both the force and displacement variables for both objects are the same. As the equation . With thus the correct mathematical calculation are:	Able to argue and can use mathematical ability along with making conclusions.
		The final conclusion is correct. If objects are pulled with the same work and experience the same displacement even though the masses of the objects are different, they will produce work by the same force.	

(Sumarni & Kadarwati, 2020). Attention to the local culture especially that is closely related to the scientific concepts needs to be strongly emphasized. Due to those two aspects i.e. creative and critical thinking as well as attention to local culture, the ethno-STEM project-based learning for high school students has been implemented and its impact on students' critical and creative thinking skills has been investigated. This study involved 230 students from seven high schools in Central Java, Indonesia. The data collection was carried out through a set of instruments to reveal the students' critical and creative thinking skills. The instruments were declared as valid based on the experts' judgment and showed an Alpha Cronbach score of 0.79 before use. The results showed that the ethno-STEM project-based learning was able to improve the average critical and creative thinking skills of students in all indicators varying from low to medium categories. The improvement of students' critical thinking skills was observed by the achievement of the N-gain score, i.e. 52 students (22.6% In addition to the low survey of students' ability to make arguments in the type of questions about critical thinking skills for advanced clarification (Herunata et al., 2020; Pradana et al., 2017; Herawati et al., 2020), CLM at least began to invite students to think about rationalization in answering the questions.

Effective learning objective means that the learning design contained in the CLM is successful in developing students' critical thinking skills for advanced clarification. The learning design in the CLM contains five phases of learning which include learning orientation, investigation, reasoning, clarification and evaluation, and reflection. These five phases are implemented synchronously using Zoom Meeting between the lecturer and the students who meet directly online.

Conclusion

The CLM design was developed to focus on increasing advanced clarification ability by adapting the advantages of IBL by paying attention to problems and suggestions resulting in two additional new phases, namely reasoning and clarification, and evaluation. There is an opportunity for students to find concepts that are carried out by thinking activities from formulating problems, making hypotheses, collecting data, and concluding what is contained in the problem orientation and investigation phase—followed by the reasoning, clarification, and evaluation activity, which impact the internalization process of advanced clarification critical thinking ability skills through guided training activities. It ended with strengthening the concepts experienced by students through the reflection phase. The learning design impacts students' ability to answer the questions given. On the pre-test, students were able to know the answer predictions but could not reveal the exact reason. The difference is that on the post-test, students have been able to show the reasons for the predictions that have been chosen. Thus, the CLM instructional design that has been developed can be effective in increasing the advanced clarification critical thinking ability. The details of the research results are as follows:

1. The two classes that are given the CLM intervention experienced an increase in advanced clarification critical thinking ability, with the same work energy, which is at the medium category.
2. The provision of CLM intervention is able to increase each indicator of advanced clarification critical thinking ability, work, and energy at a medium level, namely on indicators judge definitions, using appropriate criteria, think suppositionally, deal with fallacy labels, be aware of, and check the quality of, their own thinking (metacognition). Even able to reach the high category, namely to handle equivocation appropriately, attribute and judge unstated assumptions and Proceed in an orderly and reasonable manner appropriate to the situation.
3. The provision of CLM intervention has the same effect of increasing advanced clarification critical thinking ability in work and energy for the two classes.
4. The provision of CLM intervention has the effect of increasing every indicator of advanced clarification critical thinking ability on the subject of work and energy.

Suggestion

Although CLM has been effective in improving the critical thinking on advanced clarification aspect, but it needs to be optimized more in the future research. There is still one indicator of advanced clarification critical thinking ability which is included in the medium category, namely handle equivocation appropriately thus it needs to be improved again in order to reach high category. Meanwhile, the design of the CLM model is still focused on synchronous activities. The existence of LMS in this learning is still limited to material sharing and task submission. To make students' critical thinking skills can be more optimal, LMS can be designed as optimization of students' initial knowledge. As a result of the survey research, there is a positive correlation between the initial ability and one's critical thinking skills (Awan et al., 2017; Herunata et al., 2020; Pradana et al., 2017).critical thinking skills and achievement of 10th grade students in chemistry. In this experimental study the students of two intact groups of Govt. high school 79 SB Sargodha, were selected as experimental (N=35 The existence of the quiz feature discussion material sharing can be optimized before the lecture to prepare the prior knowledge of students. In addition, self-study assignment activities can facilitate students who have different paces of learning (Aljanazrah, 2020; Offir & Bezalel, 2008).

LIMITATION

However, the results of this study are still limited to a small sample that is only two classes in a university. Therefore, it needs to be tested elsewhere in order to find out the effectiveness of the CLM model in a wider scope. This research suggests the future researcher in order to further optimize the LMS for optimizing students' initial knowledge.

REFERENCES

Akhdinirwanto, R. W., Agustini, R., & Jatmiko, B. (2020). Problem-based learning with argumentation as a hypothetical model to increase the critical thinking skills for junior high school students. Jurnal Pendidikan IPA Indonesia, 9(3), 340–350. https://doi.org/10.15294/jpii.v9i3.19282

Aljanazrah, A. (2020). The Effectiveness Using Virtual Experiments on Students' Learning in The General Physics Lab. Journal of Information Technology Education: Research, 19(2), 976–995.

Arend, R. (2008). Learning to Teach: Belajar untuk Mengajar. Yogyakarta: Pustaka Pelajar.

Arend, R. (2012). Learning to Teach (9th Ed.). New York: McGraw-Hill.

Aunurahman. (2009). Belajar dan Pembelajaran. Bandung: Alfabeta.

Awan, R. un N., Hussain, H., & Anwar, N. (2017). Effects of Problem Based Learning on Students' Critical Thinking Skills, Attitudes towards Learning and Achievement. The Journal of Educational Research, 20(2), 20–28.

Bassham, G., & Wallace, J. M. (2013). Critical Thinking a Student ' S Introduction Fifth Edition, 27.

Davies, M. (2015). A Model of Critical Thinking in Higher Education. United States of America: Springer International Publishing Switzerland. https://doi.org/10.1007/978-3-319-12835-1_2

Dewi, R. (2020). 4 Pillars for Effective Physics Learning in The Times of Corona. Pancaran Pendidikan, 9(2), 39–46. https://doi.org/10.25037/pancaran.v9i2.289

Diani, R., Latifah, S., Jamaluddin, W., Pramesti, A., Susilowati, N. E., & Diansah, I. (2020). Improving Students' Science Process Skills and Critical Thinking Skills in Physics Learning through FERA Learning Model with SAVIR Approach. Journal of Physics: Conference Series, 1467(1). https://doi.org/10.1088/1742-6596/1467/1/012045

Duke, D. L. (1990). Teaching an Introduction. United States of America: McGraw-Hill.

Duran, M., & Dökme, I. (2016). The effect of the inquiry-based learning approach on student's critical-thinking skills. Eurasia Journal of Mathematics, Science and Technology Education, 12(12), 2887–2908. https://doi.org/10.12973/eurasia.2016.02311a

Ennis, R. H. (1985). A Logical Basis for Measuring Critical Think ing Skills. Educational Leaderschip, 43(2), 44–48. Diambil dari https://pdfs.semanticscholar.org/80 a7/c7d4a98987590751df4b1bd9adf747fd7aaa.pdf

Ennis, R. H. (2015). Critical Thinking: A Streamlined Conception. The Palgrave Handbook of Critical Thinking in Higher Education, 31–47. https://doi.org/10.1057/9781137378057_2

Ennis, R. H. (2016). Critical Thinking Across the Curriculum: A Vision. Topoi, 37(1), 165–184. https://doi.org/10.1007/s11245-016-9401-4

Facione, P. (1990). The Delphi Report: Critical Thinking: A Statement of Expert Consensus for Purposes of Educational Assessment and Instruction. Millbrae, CA: California Academic Press.

Facione, P. A. (2000). The Disposition Toward Critical Thinking: Its Character, Measurement, and Relationship to Critical Thinking Skill. Informal Logic, 20(1). https://doi.org/10.22329/il.v20i1.2254

Facione, P., & Gitten, C. A. (2016). Think Critically (Third). United Kingdom: Pearson Education.

Hake, R. R. (1999). Analyzing Change/Gain Scores. Diambil 1 April 2021, dari https://physics.indiana.edu//~sdi/AnalyzingChange-Gain.pdf

Halpern, D. (2003). Thought & Knowledge: An Introduction to Critical Thinking. Igarss 2014 (Fourth). London: Lawrence Erlabaum Associates.

Halpern, D. (2014). Thought & Knowledge: An Introduction to Critical Thinking. New York: Psychology Press.

Herawati, H., Hakim, A., & Nurhadi, M. (2020). The Effectiveness of Inquiry-Based Learning with Multiple Representation to Improve Critical Thinking Skill in Learning Electrochemistry. AIP Conference Proceedings, 2215. https://doi.org/10.1063/5.0001060

Herunata, H., Amayliadevi, R., & Widarti, H. (2020). Analisis Keterampilan Berpikir Kritis pada Indikator Memberikan Penjelasan Lebih Lanjut Materi Hidrokarbon. J-PEK (Jurnal Pembelajaran Kimia), 5(1), 47–58. https://doi.org/10.17977/um026v5i12020p047

Honebein, P. C., & Honebein, C. H. (2015). Effectiveness, efficiency, and appeal: pick any two? The influence of learning domains and learning outcomes on designer judgments of useful instructional methods. Educational Technology Research and Development, 63(6), 937–955. https://doi.org/10.1007/s11423-015-9396-3

Hughes, W., Lavery, J., & Doran, K. (2015). Critical Thinking: An Introduction to the Basic Skills-Canadian Seventh Edition. New York: Broadview Press.

Johnson, S., & Siegel, H. (2010). Teaching Thinking Skills (2nd Edition) (Vol. 66). New York: Continum Publishing.

Joyce, B., & Weil, M. (2000). Models of teaching. Amerika: A.

Joyce, B., Weil, M., & Calhoun, E. (2009). Models of Teaching. Diterjemahkan oleh Achmad Fawaid dan Ateilla Mirza. New Jersey: Prentice Hall.

Kementerian Pendidikan dan Kebudayaan. Undang-Undang No. 12 tentang Pendidikan Tinggi (2012).

Mason, M. (2009). Critical Thinking and Learning. Critical Thinking and Learning. https://doi.org/10.1002/9781444306774

McPeck, J. E. (2017). Critical Thinking and Education (12 ed.). New York: Routledge Taylor &Franci Group.

Moreno, R. (2010). Educational Psychology. Mexico: John Wiley & Sons.

Offir, B., & Bezalel, R. (2008). Surface and Deep Learning Processes in Distance Education: Synchronous Versus Asynchronous Systems. Computers & Education, 51(3), 1172–1183.

Plom, T., & Nieveen, N. (2013). Educational Design Reasearch Paert A: An Introduction. Enschede: Netherlands Institute for Curriculum Development (SLO).

Pradana, S. D. S., Parno, & Handayanto, S. K. (2017). Pengembangan Tes Kemampuan Berpikir Kritis pada Materi Optik Geometri untuk Mahasiswa Fisika. rnal Penelitian dan Evaluasi Pendidikan, 21(1), 51–64.

Prayogi, S., & Verawati, N. N. S. P. (2020). The Effect of Conflict Cognitive Strategy in Inquiry-based learning on Preservice Teachers' Critical Thinking Ability. Journal of Educational, Cultural and Psychological Studies, 2020(21), 27–41. https://doi.org/10.7358/ecps-2020-021-pray

Presiden Republik Indonesia. (2012). Peraturan Presiden Republik Indonesia Nomor 8 Tahun 2012 Tentang Kualifikasi Nasional Indonesia.

Putra, B. K. B., Prayitno, B. A., & Maridi. (2018). The effectiveness of guided inquiry and instad towards students' critical thinking skills on circulatory system materials. Jurnal Pendidikan IPA Indonesia, 7(4), 476–482. https://doi.org/10.15294/jpii.v7i4.14302

Rahmi, Y. L., Alberida, H., & Astuti, M. Y. (2019). Enhancing students' critical thinking skills through inquiry-based learning model. Journal of Physics: Conference Series, 1317(1). https://doi.org/10.1088/1742-6596/1317/1/012193

Roberson, B., & Franchini, B. (2014). Effective Task Design for the TBL Classroom. Journal on Excellence in College Teaching, 25, 275–302.

Saiz, C., & Rivas, S. F. (2011). Evaluation of the ARDESOS program: An initiative to improve critical thinking skills. Journal of the Scholarship of Teaching and Learning, 11(2), 34–51. Diambil dari http://www.pensamiento-critico.com/archivos/ardesos.pdf

Saputro, S. D., Arifin, Z., Supardi, I., Rohmah, N., & Setyawati, N. (2020). Critical Thinking Activities through Reasoning Tasks towards Cognitive Achievements, 8, 8149–8158. https://doi.org/10.13189/ujer.2020.082618

Saputro, S. D., Sarwanto, & Suparmi. (2014). Pembelajaranfisika dengan Pendekatan Konstruktivisme melalui Metode Mind Map dan Diskusi ditinjau dari Kemampuan Memori dan Verbal Siswa. Jurnal Pena Sains, 1(2), 64–75.

Scott, C. L. (2015). The Futures of Learning 2: What Kinds of Learning For 21st Century. Unesco, 1, 24–37.

Seruni, R., Munawaroh, S., Kurniadewi, F., & Nurjayadi, M. (2020). Implementation of E-Module Flip PDF Professional to Improve Students' Critical Thinking Skills through Problem Based Learning. Journal of Physics: Conference Series, 1521(4), 8–13. https://doi.org/10.1088/1742-6596/1521/4/042085

Siregar, S. (2015). Statistik Parametrik untuk Penelitian Kuantitatif: Dilengkapi dengan Perhitungan Manual dan Aplikasi SPSS Versi 17. jakarta: Bumi Aksara.

Slavin, R. (2011). Psikologi Pendidikan Teori dan Praktik (Edisi Kesembilan). Jakarta: PT Indeks.

Sumarni, W., & Kadarwati, S. (2020). Ethno-STEM Project-Based Learning: Its Impact to Critical and Creative Thinking Skills. Jurnal Pendidikan IPA Indonesia, 9(1), 11–21. https://doi.org/10.15294/jpii.v9i1.21754

Yıldırım, Ş. & Uzun, Ş. (2021). An overview of dıalogıc teaching and its impact on learning. International Journal of Education, Technology and Science (IJETS), 1(2), 135–153.

Wang, Y., Chen, A., Schweighardt, R., Zhang, T., Wells, S., & Ennis, C. (2019). The Nature of Learning Tasks and Knowledge Acquisition: The Role of Cognitive Engagement in Physical Education. European Physical Education Review, 25(2), 293–310. https://doi.org/10.1177/1356336X17724173