DEVELOPMENT OF CLARITY LEARNING MODEL TO IMPROVE STUDENT'S ADVANCED CLARIFICATION CRITICAL THINKING ABILITY ON PHYSICS COURSES

DISSERTATION

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UNIVERSITAS NEGERI SURABAYA

GRADUATE PROGRAM

PROGRAM OF SCIENCE EDUCATION

2022

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Submitted to the Postgraduate of the Universitas Negeri Surabaya to Fulfill Part of the Requirements in Obtaining a Doctor of Education Degree in the Program of Science Education

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APPROVAL

The dissertation by Sigit Dwi Saputro, NIM 19070966003, with the title Development of Clarity Learning Model to Improve Student's Advanced Clarification Critical Thinking Ability on Physics Courses, has fulfilled the requirements and was approved for the dissertation exam.

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STATEMENT LETTER
DISSERTATION WRITING RESPONSIBILITY

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I hereby state that the dissertation entitled "Development of Clarity Learning Model to Improve Student’s Advanced Clarification Critical Thinking Ability on Physics Courses " is my own work, and is not a plagiarism.

Thus this statement letter I made in truth. If later it is proven/can be proven that the dissertation is plagiarized. I am willing to bear all the consequences.

Surabaya, July 25, 2022
That state,

Sigit Dwi Saputro
NIM 19070966003

ABSTRACT

Saputro, Sigit Dwi. 2022. Development of Clarity Learning Model to Improve Students' Advanced Clarification Critical Thinking Ability in Physics Courses. Dissertation, Program of Doctoral Science Education, Postgraduate Universitas Negeri Surabaya. Promoter: Prof. Dr. Tukiran, M.Si. and co-Promoter: Dr. Zainul Arifin Imam Supardi, M.Sc.

Keywords:Clarity Learning Model, Generic Design Research Model, Advanced Classification Critical Thinking Ability.

The Vocational Education and Information Technology Study Program aims to prepare professional experts in the field of information technology. To be able to work professionally, person requires critical thinking ability. The level of critical thinking component for advanced clarification (KBK-KL) is very relevant to the achievements in the KKNI curriculum. Students' scores for KBK-KL on work and energy materials are still very low. However, so far there has been no learning model that trains KBK-KL. The purpose of this research is to produce a*Clarity Learning Model*(CLM) and learning tools as a valid, practical, and effective product thus it is appropriate to be used to improve KBK-KLonphysics courses.

The development of the*Clarity Learning Model*used the*Generic Design Research Model*(GDRM) method. This research consists of five stages, namely*problem identification, identification of tentative products and design principles, tentative products and theories, prototyping and assessment of preliminary products and theories,*and*problem resolution and advancing theory*. The research subject was*CLM*and its learning tools. The validity of the model was obtained by measuring content validity and construct validity using experts' validation technique. The practicality was measured using an observation sheet on the implementation of learning and notes on obstacles during the study. While the effectiveness was measured based on the results of the KBK-KL test based on the N-Gain score, and questionnaires to determine the level of students' responses.

The results of this study included: 1) The mean score of CLM content validity was 3.85 with the*percentage of agreement*of 97%, while the construct validity of CLM was 3.87 with the*percentage of agreement*of 98%, thus the CLM is valid both in terms of the content and construct; 2) The average range of CLM practicality scores on the wide-scale test was between 3.86 to 3.90, which was greater than the limited scale test between 3.82 to 3.86, thus CLM is included in the practical category; 3 All KBK-KL Indicators increased at least in the moderate category and students responses to CLM and its tools were included in the very strong category. Therefore, CLM is effective to be used in learning model to improve KBK-KL. The limitation of the research is that CLM has only been tested in virtual classroom learning thus students' activities cannot be observed optimally. It is suggested that CLM research needs to be tested in real-life classroom to increase interaction between lecturer and students.

PREAMBULE

Praise be to Allah SWT, Lord of the entire universe for all His abundance, favors, mercy, and guidance. Sholawat and greetings to the beloved Prophet Muhammad SAW who has always been a role model for the author so that the author can complete the preparation of this dissertation with the title " Development of Clarity Learning Model to Improve Student's Advanced Clarification Critical Thinking Ability on Physics Courses " The completion of this dissertation would not have been possible without the help of various parties. The author also expresses his incomparable gratitude and highest appreciation to:

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12. Fellow doctoral students of the Surabaya State University Science Education Study Program who motivate and help each other so that I can graduate on time
13. All parties who cannot be mentioned one by one who have provided assistance and support in completing this dissertation.

With all humility, the author realizes that there are still many shortcomings and weaknesses in writing this dissertation. I hope that all readers can provide constructive criticism and suggestions for the perfection of the dissertation. May Allah Almighty always bestow thousands of goodness on us all. Amen.

Surabaya,07 July 2022

Writer,

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1.	Conceptual Framework of Critical Thinking Skills for Work and Energy Tests Applied to Physics Learning	Periodico Tch Quimica Vol 17 No. 30, 2020 pp. 798-815 https://www.tchequimica.com/en/issue36.php	**Publish** International Journal Attached article
2.	Critical Thinking Activities through Reasoning Tasks towards Cognitive Achievements	Universal Journal of Educational Research Vol 8 No. 12B, 2020 pp. 8149-8158 https://www.hrpub.org/journals/jour_archive.php?id=95&iid=1822	**Publish** International Journal Attached article
3.	Analysis of Students Critical Thinking Ability in Distance Learning on Physics Course	International Conference of Learning on Advance Education (ICOLAE) 2021 https://icolae.ums.ac.id/2021/	**Presenter** Proof of certificate, and attached article
4.	Practicality and Problem Analysis Application of Clarity Learning Model In Physics Course	International Conference of Learning on Advance Education (ICOLAE) 2021 https://icolae.ums.ac.id/2021/	**Presenter** Proof of certificate, and attached article
5.	Design Clarity Learning Model to Improve Advanced Clarification Ability on Physics Courses	Cypriot Journal of Educational Sciences Vol. 17, No. 5, 2022 pp. 7 1549-1566 https://un-pub.eu/ojs/index.php/cjes/issue/view/475	**Publish** Reputable international journal (scopus Q3 indexed) Attached article
6.	Effectiveness of Clarity Learning Model to Improve Students' Advanced Clarification Critical Thinking Ability in Physics Courses	Pegem Journal of Education and Instruction Vol. 12. No. 3, 2022 pp. 49-58 https://www.pegegog.net/index.php/pegegog	**Publish** Reputable international journal (scopus Q4 indexed) Attached article
7.	Development Test Of Advanced Clarification Critical Thinking (TACCT) In Work And Energy Material For Student In Higher Education	International Conference of Research and Education for Educators (ICREE) 2022 https://www.masree.info/category/icree/	**Accepted** Certificate received and book chapter attached
8.	Clarity Learning Model . book	IPR of the type of book creation, ratified by the Minister of Law and Human Rights	**Rise** Attached creation registration letter

LIST OF RESEARCH PRODUCTS

1. Clarity Learning Model Book
2. Learning Tools Clarity Learning Model
   a. Semester Learning Plan (RPS)
   b. Learning Event Unit (SAP) 1Meeting: 1
   c. Learning Event Unit (SAP) Meeting: 2
   d. Learning Event Unit (SAP) Meeting: 3
   e. Learning Event Unit (SAP) Meeting: 4
   f. Student Textbook (BAM)

CHAPTER I

PRELIMINARY

A. Introduction

The Basic Physics course is a type of compulsory subject in the Informatics Education Program curriculum at Trunojoyo University Madura (TIM, 2018). The subject matter discussed includes unit quantities, measurements, kinematics, particle dynamics, work and energy, which are the same in other study programs such as Science Education, and Informatics Engineering. Mastery of Basic Physics in the Informatics Education Study Program is very important to prepare students to take courses in the field of informatics, especially robotics, because it intersects with mass and motion of objects.

In addition to mastering the concepts of physics, students need to be equipped with other skills needed to be ready to face the challenges of the times. The skills that are important to be trained in 21st century learning is critical thinking, problem solving, creative thinking, innovation, collaboration, and communication skills (Charles & Trilling, 2009). Based on the Profile of Graduates of the Informatics Education Study Program, namely preparing professional educators, experts, educational staff and technopreneurs. Everyone when working professionally requires critical and creative abilities (Suyidno, 2020). Bloom's taxonomy stages of critical thinking ability are the basis of a person in forming creative abilities, thus critical thinking skills as a research goal.

Critical thinking skills have an impact on the formation of a person's professional character (Winch & Gingell, 2008). So that the development of critical thinking skills is very supportive of achieving the objectives of implementing the undergraduate program. The purpose of implementing higher education is to prepare superior human resources, intellectuals, scientists, and cultured professionals. One of the efforts to achieve this goal, students need to be equipped with various abilities in the form of knowledge, attitudes, and skills through the learning process (Presidential Regulation of the Republic of Indonesia, 2012). Through the development of critical thinking skills for students, it is hoped that after graduating from higher education they will be better prepared to act professionally in the world of work (Siswoyo, 2007).

Another opinion, critical thinking skills are the basis of abilities that form creative abilities, and digital literacy so that they need to be trained as a provision to face a future that continues to experience dynamics due to advances in information technology (Chalkiadaki, 2018). The new era due to technological advances is called VUCA which has an acronym of volatility, namely turbulence, uncertainty which is marked by uncertainty, complexity of increasingly complex problems, and ambiguity or ambiguity of situations and conditions (Raghuramapatruni & Kosuri, 2017). The role of critical thinking skills in the VUCA era is to provide an assessment of facts or information processed by a robotic system as the basis for improving the results of the work done (Guo & Cheng, 2019).

Research results show that critical thinking skills are useful for overcoming problems that occur in the VUCA era (Raghuramapatruni & Kosuri, 2017 and Poernomo, 2020). The problem in question is a new type of problem that has never happened before. This is because the ability to think critically plays a role in analyzing the causes of problems and finding the right solution according to the character of each new problem that arises. In addition, another benefit is the ability to think critically as a basis for making decisions appropriately and accurately (Amelia *et al*., 2019).

Critical thinking skills according to Ennis (2015) are divided into basic clarification, basic conclusions, making conclusions and advanced clarification. Among the components of critical thinking skills for higher education, the advanced clarification component is very relevant to the achievement of the Indonesian National Curriculum Framework (KKNI) (Presidential Regulation of the Republic of Indonesia No. 8 of 2012). The undergraduate level is at level 6, namely students can use their mastery of knowledge to solve problems by paying attention to various sources. Thus, it is necessary to conduct a preliminary study related to the components of critical thinking for those who have or have not been mastered by students.

A preliminary study of identifying critical thinking skills starting from basic clarification, conclusion basis, making conclusions and advanced clarification has been carried out as a basis for developing a valid model. The survey method has been carried out in the Basic Physics course on work and energy materials. The research subjects are students of informatics education at Trunojoyo Madura

University with a total of 60 students. The time of conducting the survey was on 17-18 December 2020 using an adaptation of an optical material test instrument (Pradana *et al*., 2017). Categorization of critical thinking skills is divided into very less critical, less critical, moderately critical, critical, very critical (Seruni *et al*., 2020). The results of critical thinking skills are summarized in Figure 1.1.

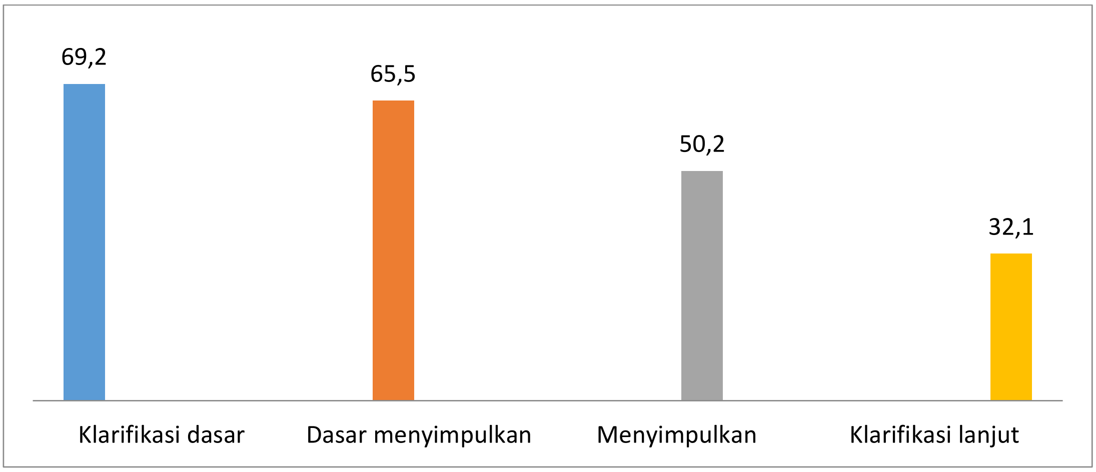


Figure 1.1 Details of Critical Thinking Ability Components: Basic Clarification, Basic Conclusion, Conclusion and Advanced Clarification.

Based on Figure 1.1 the average score of the basic clarification component is 69.2 including in the moderately critical category, the basis concludes 65.5 in the moderately critical category, concludes 50.2 in the less critical category, and advanced clarification is 32.1 in the very less critical category. Based on the preliminary study, it can be concluded that without the intervention of the learning model, students can complete the basic clarification, basic conclusion, and conclusion critical thinking tests, but they are not able to do tests on the advanced clarification component. So that students need intervention learning models that can train critical thinking ability on advanced clarification. The low score of critical thinking ability on advanced clarification needs to be studied as a basis for improvement in learning.

The results of the student's question study in the preliminary study there are three causes of the low critical thinking ability of students for advanced clarification. First, the results of student answers are identical to sources on the internet without any analysis of several sources. This is contrary to the concept of critical thinking which makes decisions by considering some information for decision making (Ennis, 1985a). The results of student answers contradict the philosophy of higher education, Winch & Gingell, (2008: 52), which states that higher education is not only at the verbal level or searching in dictionaries or books but requires a design condition that is able to generate intelligence and creativity (Winch & Gingell, 2007). 2008). This also shows that the IQF standards have not been met and the graduate profile is the ability to solve problems by paying attention to various sources of information (Presidential Regulation of the Republic of Indonesia No. 8 of 2012). The results of this study confirm previous research which obtained results that students still have difficulty connecting concepts with problems encountered in completing tests on the advanced clarification component (Sumarni & Kadarwati, 2020).

Second, students are familiar with the application of mathematical equations but have not yet reached the explanation of answers in detail about the relationship between variables. The answer shows that students are still oriented to providing information. These results contradict Tubbs, (2004) which states that the principle of learning in higher education is experience-oriented, not the provision of knowledge, because with the existence of learning experiences and optimizing the thinking process. Reinforced by the opinion of Moore, (2010) that higher education needs to pay attention to learning activities to test theories and clarify concepts learned through learning activities.

Third, students have not been able to provide a rationalization of every answer submitted, this shows that students have not mastered science. The results show that the learning objectives of the second point of higher education have not been achieved, students are expected to master the branch of science (Law No. 12 of 2012 concerning Higher Education). In addition, it also shows that the IQF standards and graduate profiles have not been fulfilled, namely the need to use knowledge mastery to solve problems (Presidential Regulation of the Republic of Indonesia No. 8 of 2012). These results confirm previous research which showed that students were not familiar with making rational arguments to answer questions in the advanced clarification component (Pradana & Parno, 2017; Sumarni & Kadarwati, 2020; Herunata *et al*., 2020;

Various learning models have been carried out to develop critical thinking skills in the field of science. Three learning models that are often applied in science include the inquiry learning model (IBL), problem-based learning (PBL) and project-based learning (PjBL) (Scott, 2015; Dewi, 2020). There are other innovative learning models that are often used, such as FERA in biology learning, Diani *et al*., 2020), Flipped chemistry learning (Styers *et al*., 2018). The detailed description of each learning model has trained critical thinking indicators as follows.

First, the IBL model contributes to training various indicators of critical thinking skills. IBL can develop critical thinking skills on analytical indicators (Duran & Dökme, 2016; Yuliska & Syafriani, 2019; Gómez & Suárez, 2020; Greenwald & Quitadamo, 2014; Gupta *et al*., 2015; Makmur *et al*., 2019; Prayogi & Verawati, 2020; Farah & Ayoubi, 2020; Putra *et al*., 2018; Sönmez *et al*., 2019; Jainal & Yosephine Louise, 2019). Likewise, evaluation indicators (Duran & Dökme, 2016; Yuliska & Syafriani, 2019; Gómez & Suárez, 2020; Gupta *et al*., 2015; Ku *et al*., 2014; Prayogi & Verawati, 2020; Putra *et al*., 2018; Muskita *et al*., 2020). Next are inference indicators (Duran & Dökme, 2016; Rahmi *et al*., 2019; Pursitasari *et al*., 2020; Maknun, 2020; Prayogi & Verawati, 2020), indicators of interpretation (Duran & Dökme, 2016; Greenwald & Quitadamo, 2014; Farah & Ayoubi, 2020; Putra *et al*., 2018; Muskita *et al*., 2020), explanatory indicators, and self-regulation (Duran & Dökme, 2016; Putra *et al*., 2018). The critical thinking component starts from basic clarification, decision basis, advanced clarification, strategies and tactics (Rahmi *et al*., 2019; Pursitasari *et al*., 2020, Irwanto *et al*., 2018; Herawati *et al*., 2020; Wardani *et al*., 2017). Herawati *et al*., 2020; Wardani *et al*., 2017). Herawati *et al*., 2020; Wardani *et al*., 2017).

Other indicators that have been developed in IBL are evaluating information, processing information, organizing information, conveying ideas and making reports (Irwanto *et al*., 2019; Gupta *et al*., 2015; Hwang & Chen, 2017). Synthesis indicators (Yuliska & Syafriani, 2019; Gómez & Suárez, 2020; Gupta *et al*., 2015; Makmur *et al*., 2019; Maknun, 2020; Putra *et al*., 2018; Wardani *et al*., 2017; Jainal & Yosephine Louise, 2019), indicators of classification, comparison, and explanation (Maknun, 2020), indicators of knowledge implementation (Gupta *et al*., 2015; Makmur *et al*., 2019; Jainal & Yosephine Louise, 2019), logic indicators, and problem solving (Sönmez *et al*., 2019). Likewise, IBL has been developed on indicators of making arguments and decision making (Ku *et al*., 2014; Prayogi & Verawati, 2020; Sönmez *et al*., 2019).

However, so far IBL learning only trains two indicators of critical thinking ability on advanced clarification, namely indicators assessing phenomena based on appropriate criteria (Irwanto *et al*., 2018; Zain & Jumadi, 2018; Rahmi *et al*., 2019; Herawati *et al*., 2020; Maknun, 2020; Pursitasari *et al*., 2020). Second, indicators identify assumptions that are not stated (Irwanto *et al*., 2018; Herawati *et al*., 2020; Maknun, 2020; and Pursitasari *et al*., 2020). Thus, IBL has the opportunity as the basis for developing a model that trains the seven critical thinking abilities on advanced clarification.

Second, the PBL model contributes to training various indicators of critical thinking skills including indicators of analysis, evaluation, explanation, inference, interpretation, self-regulation (Alsarayreh, 2021; Rehmat & Hartley, 2020). Likewise, indicators of basic clarification, basic conclusions, inference, and advanced clarification (Mundilarto & Ismoyo, 2017; Alsarayreh, 2021; Seruni *et al*., 2020), indicators of organizing information and presentation reports (Sinprakob & Songkram, 2015), indicators of analysis, synthesis and evaluation (Awan *et al*., 2017), indicators of comparison, classification and logic (Alsarayreh, 2021; Siew & Mapeala, 2014), and indicators of decision making and problem solving (Fadilla *et al*., 2021; Suhirman *et al*., 2021; Seruni *et al*., 2020). Another study uses Problem-Based Learning Method Supported by Web 2.

However, so far PBL learning only trains some indicators of critical thinking ability on advanced clarification, namely indicators of assumption identification and predictive thinking (Mundilarto & Ismoyo, 2017). Only one indicator identifies assumptions (Seruni *et al*., 2020; Alsarayreh, 2021). Thus, PBL learning has the opportunity to be the basis for developing a model that trains seven indicators of critical thinking ability on advanced clarification.

Third, the PjBL model contributes to training various indicators of critical thinking skills including indicators of analysis, evaluation, explanation, inference, interpretation, self-regulation (Alawi & Soh, 2019; Al-Khrisha, 2021; Taufiq *et al*., 2020; Issa & Khataibeh, 2021). Likewise, PjBL has been used to develop critical thinking skills on indicators of basic clarification, basic conclusions, inference, and advanced clarification (Al-Khrisha, 2021; Sumarni & Kadarwati, 2020; Astra *et al*., 2019), organizing information and presentation reports. (Handhika *et al*., 2018; Issa & Khataibeh, 2021; Astra *et al*., 2019), indicators of analysis, synthesis and evaluation (Alawi & Soh, 2019; Muhdhar *et al*., 2021), indicators of argument and decision making (Astra *et al*., 2019), logic indicators (Al-khrisha, 2021), problem solving indicators (Issa & Khataibeh, 2021). The results of other research on STEM science lessons through PjBL have an impact on the majority of students being in the advanced thinker category with a percentage of 41% of students belonging to the low outcome category (Mutakinati *et al*., 2018).

However, so far PjBL learning only trains some indicators of critical thinking ability on advanced clarification, namely indicators for identifying assumptions, and evaluating statements (Sumarni & Kadarwati, 2020). Only one indicator identifies assumptions (Al-khrisha, 2021; Astra *et al*., 2019). Thus, PjBL learning has the opportunity to become the basis for developing a model that trains seven indicators of critical thinking ability on advanced clarification.

Fourth, other innovative learning used in developing critical thinking skills including Structuring a new socioscientific Issues (SSI) has been proven to improve critical thinking skills on indicators of analysis, evaluation and making conclusions in biology lessons (Davut Gul & Akcay, 2020). Likewise, Peer-Led Team Learning and The Science Writing and Workshop Templates in chemistry learning can affect critical thinking skills on indicators of analysis, interpretation, evaluation and explanation (Stephenson *et al*., 2019). Another learning, namely Blended learning applied to physics lessons, affects critical thinking skills on indicators of question analysis, answer analysis, induction logic, concluding, evaluating statements, and making physics learning decisions (Sulisworo *et al*., 2020). Flipped in chemistry courses can improve critical thinking skills on indicators of information evaluation and problem solving (Styers *et al*., 2018). Strengthened by Focus, Explore, Reflect and Apply (FERA) learning on effective chemistry learning to improve critical thinking skills on components, basic clarification, decision making, conclusion, and advanced clarification (Diani *et al*., 2020).

Innovative learning advantages such as SSI (Davut Gul & Akcay, 2020), Peer-Led Team Learning and The Science Writing and Workshop Template

(Stephenson *et al*., 2019), Blended Learning (Sulisworo *et al*., 2020), Flipped (Styers *et al*., 2020), al., 2018), and FERA (Diani *et al*., 2020) affect critical thinking skills. However, only two studies measure critical thinking ability on advanced clarification. First, Sulisworo *et al*., (2020) have just measured advanced clarification on indicators evaluating statements. Meanwhile, Diani *et al*.'s research (2020) only measures indicators to assess phenomena based on appropriate criteria and identify assumptions.

Based on a review of research journals, it can be concluded that both IBL, PBL, PjBL, FERA, Blended Learning have contributed to advanced clarification critical thinking skills. However, these various learning models have not been able to fully measure the seven indicators of critical thinking ability on advanced clarification. The new IBL, PBL, PJBL, FERA and Blended Learning learning models are used for developing critical thinking ability on advanced clarification on indicators of assessing phenomena based on appropriate criteria, and identifying assumptions that are not stated. Meanwhile, PBL only develops critical thinking skills, advanced clarification on predictive thinking indicators and identifying assumptions that are not stated. Based on the CPMK analysis in the Basic Physics course as a compulsory subject for study programs in the field of information technology, as a course to equip concepts. The IBL model was chosen as the basis for developing a new model to train critical thinking ability on advanced clarification due to its role as concept formation (Arend, 2008). While PBL is more focused on applying knowledge to solve problems (Barett, 2017; Mahnaz, *et. al*. 2019). PjBL is a learning activity by connecting extensive knowledge to solve problems through an experiment (Krauss & Boss, 2013; Tan, 2016). While PBL is more focused on applying knowledge to solve problems (Barett, 2017; Mahnaz, *et. al*. 2019). PjBL is a learning activity by connecting extensive knowledge to solve problems through an experiment (Krauss & Boss, 2013; Tan, 2016). While PBL is more focused on applying knowledge to solve problems (Barett, 2017; Mahnaz, *et. al*. 2019). PjBL is a learning activity by connecting extensive knowledge to solve problems through an experiment (Krauss & Boss, 2013; Tan, 2016).

Based on a preliminary study review, the low critical thinking ability for advanced clarification is due to the lack of familiarity with reasoning (Mutikanati, *et. al*, 2018; Sumarni & Kadarwati, 2020). So, it is necessary to pay attention to the reasoning factor as a consideration for the development of learning models. As the results of the study show that reasoning ability is useful for explaining decisions to others (Butcher *et al*., 2019; Kuhn, 2018). Because through reasoning someone will be able to make an argument (Konstantinidou & Macagno, 2013). In addition, there are suggestions for research results to improve critical thinking ability on advanced clarification through: optimizing exercise and guidance on the completion of critical thinking skills during learning (Diani *et al*., 2020; Herunata *et al*., 2020). Next consider the IBL learning model because as a model for preparing students' concepts (Arend, 2008), this is in accordance with the objectives of the CPMK for Basic Physics and contribute to the development of critical thinking skills. In addition, researchers also pay attention to the distance learning factor, because of the demands for distance learning due to the Covid 19 (Directorate General of Higher Education, 2020). Based on these various considerations, models and learning tools were developed to improve critical thinking ability on advanced clarification of students in physics courses. In order for students to be optimal in making advanced clarifications, the principle of clarity or clarity of concept understanding is needed (Bolkan, 2007; Limperos & Frisbi, 2020). So this research with the theme "Development of Clarity Learning Model (CLM) to Improve Critical Thinking Ability of Advanced Clarification of Students.

B. Restrictions of the Problem

The large-scale trial was tested on a limited scale on students who took the Basic Physics course at the Study Program of Informatics Education, Trunojoyo University Madura, Study Program of Information Technology Education, University of Lampung, and Study Program of Informatic Education, IVET Semarang. The research data includes the CLM model validation sheet, CLM implementation observation sheet, research constraint sheet, advanced clarification critical thinking ability test, and student response questionnaires.

C. Formulations of the Problem

In general, the formulation of the main problem in this study is: "How is the validity, practicality, and effectiveness of the results of CLM development?". The details of the problem formulation are described as follows.

1. How are some validities of CLM learning models and tools that have been developed to improve critical thinking ability on advanced clarification?

   The formulation of the problem is described as follows:

a. How is the content validity of the CLM that has been developed to improve critical thinking ability on advanced clarification?

b. How is the validity of the CLM construct that has been developed to improve critical thinking ability on advanced clarification?

c. How is the validity of the CLM learning media developed to improve critical thinking ability on advanced clarification?

2. How are some practicalities of CLM that have been developed to improve critical thinking ability on advanced clarification of students?

   The formulation of the problem is described as follows:

   a. How is the implementation of learning using the developed CLM?

   b. What are the obstacles that arise when implementing the developed CLM?

3. How are some effectiveness CLM that have been developed to improve critical thinking ability on advanced clarification?

   To answer the problems posed, the problem is broken down into several sub-problems as follows:

   a. How are the improvements in a student's critical thinking ability on advanced clarification after following the CLM?

   b. How are the students respond to the CLM models and learning media?

D. Purposes of the Research

In general, the purpose of this research is to produce a valid, practical, and effective CLM to improve critical thinking ability on advanced clarification. Specifically, this research aims to:

1. Describing some validity CLM which have been developed to improve critical thinking ability on advanced clarification.

   The objectives are described as follows:

   a. Describe CLM content validity which has been developed to improve critical thinking ability on advanced clarification.
   b. Describe the construct validity of CLM which has been developed to improve critical thinking ability on advanced clarification.
   c. Describing the validity of CLM learning media which was developed to improve students' critical thinking ability on advanced clarification.
2. Describe some practicality of CLM which have been developed to improve critical thinking ability on advanced clarification. The objectives are described as follows:
   a. Describe the implementation of learning using CLM developed.
   b. Describe any obstacles that arise when implementing CLM.
3. Describe effectiveness of CLM which have been developed to improve critical thinking ability on advanced clarification:
   a. Describe the improvement of critical thinking ability on advanced clarification after learning with CLM which has been developed.
   b. Describing student responses to the CLM learning tool model which has been developed.

E. Benefit

CLM is developed through theoretical and empirical studies, so it is hoped that it will provide theoretical and practical benefits in an effort to improve the quality of learning, especially Basic Physics in higher education and other science learning. In detail the benefits of research are as follows:

1. Practical benefits

a. It is hoped that it can be a reference for educators and lecturers of Basic Physics courses, especially to utilize CLM-based physics learning models and tools.

b. The learning model developed produces learning tools (Teaching Books, Semester Learning Plans (RPS), Learning Program Units (SAP) and advanced clarification critical thinking skills test instruments are expected to improve advanced clarification critical thinking skills.

c. The findings of this study are expected to make a real contribution as an effort to improve the quality of basic physics learning in universities

d. As input, reference, and comparison for other researchers who will conduct research on the development of physics learning models.

2. Theoretical benefits

The results of this study are expected to contribute ideas in improving the quality of education, especially in student physics learning, especially:

a. Discovering the principles of the Basic Physics learning model using CLM for increase advanced clarification critical thinking skills.

b. In addition, studies on basic physics learning are relevant by using advanced clarification critical thinking skills.

F. Definition of Terms

This study has several definitions of terms that need to be further elaborated, including:

1. The learning model is the achievement of learning objectives through a careful and structured plan to help students master information, generate ideas, have skills, build ways of thinking and the meaning of learning.
2. CLM stands for Clarity Learning Model is a learning plan that is inspired by the principle of clarity or clarity, namely learning that prioritizes conceptual clarity. CLM development pays attention to capabilities reasoning, the ability to make arguments, and inquiry learning models to improve critical thinking ability on advanced clarification.
3. The ability to think critically for advanced clarification with abbreviations (KBK-KL) is a person's ability to describe/explain in detail based on science. The indicators of critical thinking ability on advanced clarification are assessing phenomena based on appropriate concepts, evaluating one's line of thought, identifying unstated assumptions, predictive thinking, handling label errors, metacognitive thinking, n complete problem in order.
4. CLM content validity is the quality of the learning model in terms of the needs of the development of the model based on the latest knowledge.
5. The validity of the CLM construct is the quality of the model in terms of the rational aspect of the model and syntax, social systems, reaction principles and model support systems, instructional impacts and model accompaniment

impacts, model classroom management learning environment, implementation of model evaluation.

6. The validity of CLM learning tools is the quality of learning tools developed based on CLM needs.
7. The practicality of CLM is the realistic level of ease of implementing CLM for its users.
8. The effectiveness of CLM is the level of achievement or real impact of CLM on the goals that have been set.

G. Assumption

The assumptions of this research are as follows:

1. Observers objectively assess the implementation of CLM learning, and the obstacles to CLM learning.
2. Students fill out the questionnaire well, the results reflect the student's response to the CLM learning model and tools objectively.
3. The score for the assessment of critical thinking ability on advanced clarification reflects the actual ability of students.

CHAPTER II

LITERATURE REVIEW

A. The Importance of Critical Thinking Skills in Achieving a Graduate Profile of Study Programs

Based on the decision of the Minister of Research, Technology, and Higher Education of the Republic of Indonesia Number 257/M/KPT/2017 concerning Names of Study Programs in Higher Education, the Informatics Education Study Program is a clump of education science with code 710 including the sub-cluster of technology and vocational education with code (786). Each study program has a profile of graduates to be achieved. The selection of graduates from the Informatics Education Study Program at Trunojoyo Madura University took into account the decisions of the study program associations, namely the Indonesian Computer Science Higher Education Association (APTIKOM) and the Indonesian Technology and Vocational Education Association (APTEKINDO). As a study program included in the clump of vocational education and technology, the Informatics Education Study Program has special characteristics which are described in Table 2.1.

Based on Table 2.1, the achievement profile of graduates of the Informatics Education Study Program including educators, experts, educational staff and professional technopreneurs, critical thinking skills are needed. Achieving professionalism in work requires communication skills, digital literacy, and critical thinking. Among these abilities, critical thinking skills are the basis for supporting other abilities (Bassham & Wallace, 2013; Ennis, 2016, Facione & Gitten, 2016; Winch & Gingell, 2008). The role of critical thinking skills is to optimize intellectual capacity to get the best decisions (Davies, 2015; Ennis, 2016).

Table 2.1 Profile of Graduates of the Informatics Education Study Program

No.	Profile	Profile Description
1.	Professional Educators	Educators in the field of Information Technology expertise.
2.	Professional Experts	Experts in the field of Information Technology in the industrial world as well as in both public and private institutions, among others as: programmers, systems analysts, network administrators, data analysts, and multimedia designers in information technology companies (software houses).
3.	Professional Education Personnel	Educational staff in the field of laboratory management and school administration related to Information Technology.
4.	Professional Technopreneur	Entrepreneurs related to information technology.

In addition, critical thinking skills also support the achievement of general skills of the Informatics Education Study Program contained in the AchievementsGraduates of Vocational Education Information Technology National Standards for Higher Education (Permendikbud, 2014). The general skills contain the following:

1. able to apply logical, critical, systematic, and innovative thinking in the context of the development or implementation of science and technology that pays attention to and applies the value of local wisdom in accordance with their field of expertise;
2. able to demonstrate independent, quality, and measurable performance;
3. able to examine the implications of the development or implementation of science and technology that pays attention to and applies the value of local wisdom in accordance with their expertise based on scientific

principles, procedures and ethics in order to produce solutions, ideas, designs or art criticism, compile scientific descriptions of the results of their studies in the form of a thesis or assignment report end, and upload it on the college website;
4. able to make appropriate decisions in the context of solving problems in their area of expertise, based on the results of information and data analysis;

The ability to think critically is also needed by students in facing the new era, namely VUCA with the acronym volatility, namely turbulence, uncertainty which is characterized by uncertainty, complexity of problems that are increasingly complex, and ambiguity or ambiguity of situations and conditions (Raghuramapatruni & Kosuri, 2017). In this era, a person is required to be able to make decisions quickly based on facts (Guo & Cheng, 2019). As the results of Chalkiadaki's research, (2018) show that critical thinking skills are the basic skills that need to be trained as a provision to face a future that continues to experience dynamics due to advances in information technology.

Likewise, the ability to think critically is one of the skills that is as important as other skills needed in 21st century society. As the contents of the partnership for 21st century skills, there are equally important components, namely critical thinking skills, problem solving, collaboration, communication, creative thinking, digital literacy and mastery of information and communication technology (Charles & Trilling, 2009; Frydenberg & Andone, 2011). The ability to think critically is the basis for the formation of other abilities, so it needs to be trained earlier before other abilities.

Based on the achievements of study program graduates, general skill attainment of vocational education study programs, challenges of the VUCA era, and 21st century society, it can be concluded that critical thinking skills are very relevant to be taught to students of the Informatics Education Study Program andInformation Technology Vocational Educationand is a student's need to face future challenges.

B. Concept of Critical Thinking Ability

Based on the results of the analysis of graduate profiles, and learning achievement is one of the important skills for students to trainInformation Technology Vocational Education Is the ability to think critically. Thus, the concept of critical thinking needs to be studied in depth from various points of view of experts to obtain comprehensive information about the meaning of critical thinking skills. The expert opinions that will be studied include Ennis, Halpern, Paul and Elder, McPeck, Siegel, Facione, and other public opinion.

The first expert, Enis argues that critical thinking skills are reflective thinking to make decisions that can be trusted and can be done (Ennis, 1985a). The main basis of critical thinking skills such as observation, conclusion, generalization, logic and evaluation. Critical thinking is the basis for the development of various skills. Ennis has a strong view that various skills have a correlation with critical thinking skills, and can be taught in certain fields of science to be changed from one domain to another (Mason, 2009:3). Ennis consistently divides critical thinking consisting of critical thinking abilities and critical thinking dispositions (Ennis, 1987a, 1987b, 2015, 2016).

The second expert, Halpern has a view that according to him critical thinking skills are directed thinking and aim to formulate problems and the basis for making decisions. Strong thinking can only be done based on accurate knowledge (Halpern, 2003:6). Critical thinking has two parts, namely skills in the form of argument analysis based on evidence, making decisions or problem solving and disposition which includes open thinking (Halpern, 1998). Critical thinking skills are based on cognitive psychology, one of the important things to teach critical thinking skills is to practice the relationship between problems with one another. Teaching that focuses on literacy skills to students will quickly make decisions when faced with a problem (Halpern, 1999).

The third expert, the ability to think critically according to the Third Paul and Elder is the art of analyzing and evaluating thinking with the aim of making a better contribution. In addition, for him the ability to think critically is closely related to other skills (Paul & Elder, 2014). Critical thinking ability is divided into two, namely strong and weak critical thinking skills. Critical thinking skills require deep knowledge in their field to make decisions and humility (Paul, 1982). Critical thinking can be divided into two parts, namely skills, namely argument analysis based on evidence, concluding, identification of assumptions while disposition contains a willingness to find out more, humility, courage, integrity and perseverance (Paul, 1992).

The fourth expert, McPeck's critical thinking ability is a skill to solve problems on a particular subject. Understanding or knowledge of the object being studied is the main thing and the problems felt by society in general (McPeck, 2017). Critical thinking is not dreaming, or daydreaming but thinking with a specific purpose (McPeck, 1981). Critical thinking requires scientific knowledge, so that every decision can be accounted for.

McPeck argues that critical thinking skills are focused on a particular field of science. The basis of critical thinking depends on the understanding and concepts of knowledge acquired. The critical thinking process is carried out through an inductive process, namely through generalization of material content and the structure of the field of science (Mason, 2009). A person who can think critically requires disposition and skills. Through the development of the disposition, namely curiosity due to reflective thinking, skepticism will be able to optimize critical thinking skills (McPeck, 1981).

The fifth expert, Siegel's point of view, critical thinking ability is based on the strength of one's rationality in providing an appropriate explanation (Siegel, 1991:23). This means that a person must have the ability to convince, rationality of thinking in the field of material that is mastered and systematically to build explanations. Each explanation can be made criteria according to the ability of rationality. Learn to think critically using mental processes such as observing, categorizing, selecting and evaluating. The most important thing from the process will not be separated from the context of the specific material (Johnson & Siegel, 2010). Critical thinking has a special characteristic, namely rationality, the critical thinking domain consists of critical thinking skills, namely reasoned judgment,

The sixth expert, according to Facione, critical thinking skills are a person's cognitive skills which include interpretation, analysis, evaluation, conclusions, explanations, and self-regulation that have characteristics thinker good, clear, logical, wise, pay attention to facts, open to alternatives (Facione, 2009:5). The ideal critical thinker has the habit of being curious, knowledgeable, honest in the face of personal bias, wise in making judgments, understanding major issues, and always considering evidence (Facione, 1990). Guided practice and continuously raising the level of difficulty of the problem or question draining the mind make critical thinking skills stronger (Facione & Gitten, 2016). Holding ethical standards as an important critical disposition (Facione, 1990).

Apart from the critical thinkers already mentioned, there are other opinions such as Judge *et al.*, (2009) critical thinking is the examination of ideas or information from objects by paying attention to one's values and attitudes. The main point of critical thinking is that evidence is analyzed and relevant. Next, Moon (2007) argues that critical thinking is the challenge of ideas by evaluating different perspectives or being able to think wisely. Critical thinking is defined by Wallace (2001) as a variety of skills and intellectual dispositions to identify, analyze arguments and truth claims to overcome biased prejudices. Likewise, Dunn *et al.*, (2009) critical thinking is a process of evaluating reasoning, reflective processing, and active cognitive strategies for making decisions.

Based on the opinion of experts, there are similarities in the concept of the definition of critical thinking skills, namely activities that aim to make rational decisions by considering facts or information and being able to explain them to others (Ennis, 1985a; Halpern, 1999; McPeck, 1981; Facione, 2009; Siegel, 1991). On the other hand, the difference of opinion lies in the scope of the field of science. The first opinion is that critical thinking skills are special in that they can only be applied to one field of science (Halpern, 2003; McPeck, 2017; and Johnson; Siegel, 2010). The second opinion is that critical thinking skills are general, namely this ability is general and can be applied in various fields of science (Ennis in Mason, 2009; Paul & Elder, 2014:1; Facione, 2009).

Based on the research objectives, Ennis' critical thinking skills were chosen as the basis for training students because they have general critical thinking concepts. So that each course in the Informatics Education Study Program curriculum can be trained in critical thinking skills to students. The Basic Physics course will be used to train students' critical thinking skills.

C. Considerations for Selection of Advanced Clarification Critical Thinking Skills (KBK-KL)

Ennis divides critical thinking skills into several components, including basic clarification, the basis for conclusions, inference, advanced clarification and additional abilities (Ennis, 2015, 2016). The division of components of critical thinking skills in the form of a taxonomy (Ennis, 1987a). Thus, the components of critical thinking have different levels. The taxonomy of critical thinking skills is as shown in Table 2.2.

Table 2.2 The Division of Critical Thinking Taxonomy According to Ennis

Component	Indicator
Basic Clarification	1. Focus on the question 2. Analyze arguments 3. Ask and answer clarifying questions 4. Understanding graphs and math
Basis for Concluding	5. Assess source credibility 6. Observation and assessing the observation report

	7. Use their background knowledge, and knowledge
Inference	8. Perform deductions and justify deductions 9. Perform induction and justify induction 10. Making and assessing value judgments Important factors
Advanced clarification	11. Assess phenomena based on appropriate concepts 12. Evaluating a person's line of thought 13. Identify unstated assumptions 14. Predictive thinking 15. Handling label errors 16. Metacognitive thinking 17. Complete Problem in order
Additional Skills	18. Using the right strategy for discussion

Based on Table 2.2 of the taxonomy of critical thinking skills, the advanced clarification component (KBK-KL) shows that students are required to optimize their intellectual abilities, so that they get the best decisions and have the ability to make explanations of the decisions that have been taken (Davies, 2015:50; Ennis, 2015). 2015). This ability will support the character of a person with professional performance (Facione, 2016; Wallace, 2001). Thus KBK-KL is relevant to the purpose of providing higher education in undergraduate programs in higher education to prepare students to become intellectuals and/or scientists who are cultured, and have competitiveness so that they are able to work professionally (Ministry of Education and Culture 2012, Article 18:2).

KBK-KLchosen as the basis of research, because KBK-KL supports the achievement of higher education goals, KKNI and learning outcomes. The basis for each consideration is described as follows. First, KBK-KL supports the achievement of higher education goals. Law No. 12 Regarding Higher Education, 2012 in article 5 contains the objectives of higher education, including:

1. developing the potential of students to become religious individuals, possessing superior human resources;

2. produce graduates who have mastery of concepts or fields of knowledge that have been studied;
3. the production of Science and Technology through a scientific attitude that is beneficial for the interests of the nation and state; and
4. the realization of community service that is able to prosper and educate the community.

Based on the basis of higher education, the ability to think critically for advanced clarification supports the achievement targets of higher education in article five (5) point b, namely students need to have mastery of science(Ministry of Education and Culture, 2012).Evidence from mastery of science students are not only able to conclude but must be able to assess a phenomenon by making definitions by considering definitions using appropriate criteria, handling misunderstandings, identifying unstated assumptions, suppositional thinking (making estimates), handling wrong claims, thinking metacognitively, and solve problems sequentially.

KBK-KL supports the achievement of KKNI. The learning achievement with a bachelor's degree based on the KKNI is equivalent to qualification level 6 (Presidential Regulation of the Republic of Indonesia, 2012) which includes:

1. Ability to solve problems encountered by using the field of knowledge that has been owned.
2. The ability to formulate procedural problems through certain theoretical concepts that he has mastered in depth.
3. Able to make decisions by paying attention to information from various alternative solutions, both independently and in groups.
4. Have an attitude of responsibility at work alone or in groups.

Based on the content of the objectives of the undergraduate program, the skills needed are problem solving, formulating problems with concepts possessed and the ability to make appropriate decisions based on information and data analysis, and being able to provide instructions in choosing various alternative solutions are characteristics of KBK-KL. This is because KBK-KL requires someone to be able to evaluate facts or phenomena, predict, and work sequentially using the knowledge they have.

KBK-KL supports the achievement of learning outcomes, to determine the relationship of KBK-KL indicators with the objectives of Study Program Learning Outcomes as shown in Figure 2.1.

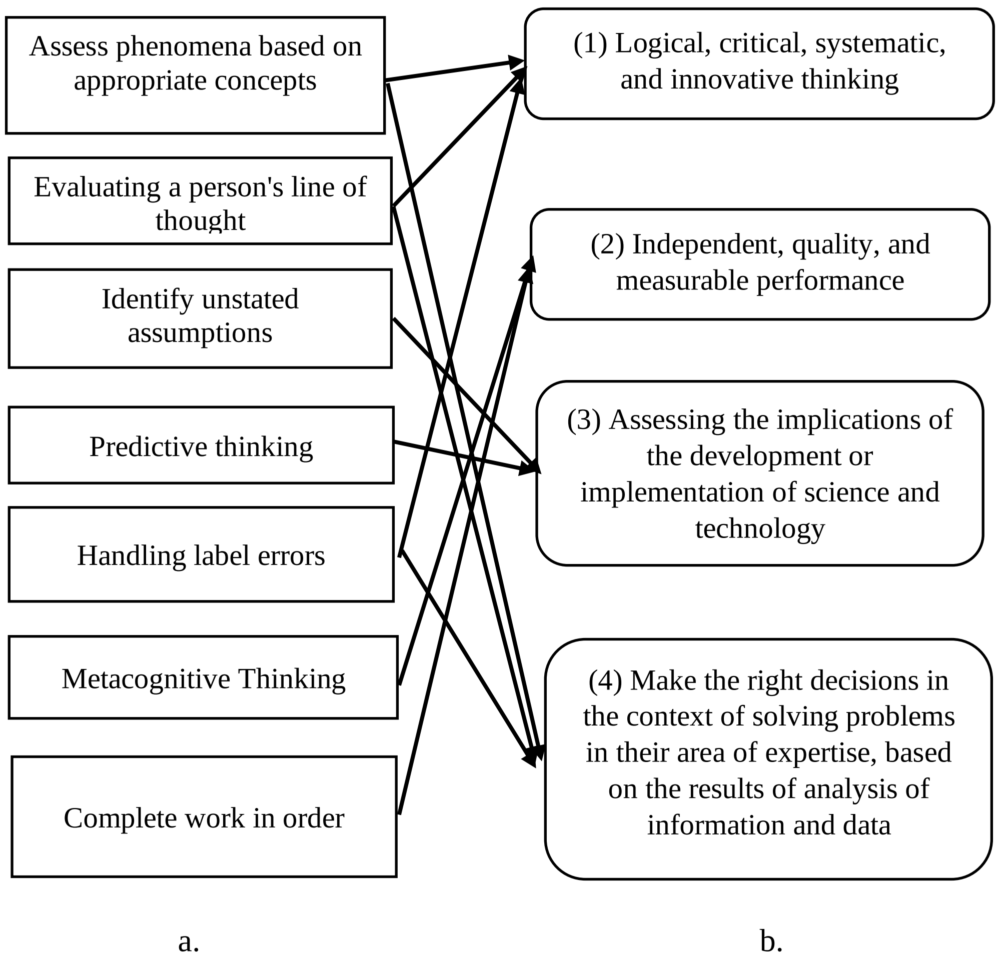


Figure 2.1. Relationship of KBK-KL (a) with Study Program Learning Outcomes (b)

Based on Figure 2.1, it shows that the Learning Outcomes of the Study Program for point 1 students have systematic and innovative logical thinking supported by KBK-KL with indicators of the ability to assess phenomena based on appropriate criteria, evaluate one's line of thought, and handle label errors. While point 2 students are able to show independent, quality, and measurable performance supported by KBK-KL on indicators of metacognitive thinking, and complete work in order.

Point 3 students are able to examine the implications of developing or implementing science and technology that pays attention to and applies the value of local wisdom according to their expertise based on scientific principles, procedures and ethics in order to produce solutions, ideas, designs or art criticism, compose a scientific description of the results of their studies in the form of a thesis. or final project report, and upload it on the university website supported by KBK-KL on indicators of handling unstated assumptions and predictive thinking. Finally, point 4, students are able to make appropriate decisions in the context of solving problems in their field of expertise, based on the results of information and data analysis; KBK-KL with indicators of the ability to evaluate concepts based on appropriate criteria, evaluate a person's line of thought, and handle label errors.

D. KBK-KL Research Evaluation

The purpose of evaluating KBK-KL research is to obtain valid information as a basis for research considerations in optimizing research objectives, namely increasing student KBK-KL. Table 2.3 is a summary of various studies using the KBK-KL measurement.

Table 2.3 The Results of the Research on Critical Thinking Ability in the Advanced Clarification Component

No	Research identity	Research subject	Method	Results
1.	Mundilarto & Ismoyo, (2017)	High school students in physics	Experiment, comparing the problem-based learning model with the control class	Problem-based learning affects critical thinking skills. **Notes:**KBK-KL not deciphered
2.	Puspita *et al*., (2017)	Middle school students in fluid subjects	Survey	The average critical thinking ability is still low. KBK-KL is included in the very low category
3.	Pradana & Parno, (2017)	Student in physics course	Survey	The average critical thinking ability is low. In the KBK-KL component the average value is 51.7
4.	Wardani *et al*., (2017)	High school chemistry lessons	Experiment, comparing the inquiry learning model with the control class	Inquiry learning affects critical thinking skills **Notes:**KBK-KL not deciphered
5.	Irwanto *et al*., (2018)	Student teacher candidates for science subjects	Experiment, comparing POGIL model with control class	POGIL learning affects critical thinking skills **Notes:**KBK-KL not deciphered

No	Research identity	Research subject	Method	Results
6.	Zain & Jumadi, (2018)	High school students in physics	Experiment, comparing the inquiry learning model with the control class	Inquiry learning affects critical thinking skills. The average score of the KBK-KL component is 30.5
7.	Rahmi *et al.*, (2019)	High school student in biology subject	Experiment, comparing the inquiry learning model with the control class	Inquiry learning affects critical thinking skills. The average score on the KBK-KL component is 77.7
8.	Sumarni & Kadarwati, (2020)	High school student chemistry subject	Experiment, comparing project-based learning model with control class	Project-based learning models affect critical thinking skills. The N-Gain score on KBK-KL is included in the low category
9.	Diani *et al.*, (2020)	High school student chemistry subject	Experiment, comparing the FERA model with the control class	FERA affects critical thinking skills. The average score on KBK-KL is 71.5
10.	Davut Gul & Akcay, (2020)	Science teacher candidates	Experiment, comparing SSI model with control class	There is no effect of the SSI model on critical thinking skills. However, there is an increase in critical thinking skills **Notes:**KBK-KL not deciphered
11.	Herawati *et al.*, (2020)	Chemistry subject SMK students	Experiment, comparing the inquiry learning model with the control class	The inquiry learning model has an effect on critical thinking skills. KBK-KL average score 69
12.	Maknun, (2020)	Physics subject vocational high school	Experiment, comparing the inquiry learning model with the control class	The inquiry learning model has an effect on critical thinking skills. The average score of KBK-KL is 87.5

No	Research identity	Research subject	Method	Results
13.	Pursitasari *et al*., (2020)	Junior high school	Experiment, comparing the inquiry learning model with the control class	The inquiry learning model has an effect on critical thinking skills. The Average Score on KBK-KL is 29
14.	Herunata *et al*., (2020)	High school student in chemistry subject	Survey	The average of the KBK-KL component indicators is included in the fairly critical category.

Based on Table 2.3, it can be seen that without any learning intervention or survey research results, learners have difficulty working on all critical thinking components, especially the KBK-KL component (Herunata *et al*., 2020; Pradana *et al*., 2017; Puspita *et al*., 2017). Meanwhile, research on learning interventions with various models shows that learning models have contributed to improving critical thinking skills.

Although the KBK-KL Indicator was included as part of the research, the results were not described because the researchers only calculated the overall average of the components of critical thinking skills (Davut Gul & Akcay, 2020; Irwanto *et al*., 2019; Mundilarto & Ismoyo, 2017; Wardani *et al*. ., 2017). The inquiry learning model has the opposite results, KBK-KL can reach the target (Maknun, 2020; Rahmi *et al*., 2019), and other research results KBK-KL does not reach the target (Pursitasari *et al*., 2020; Zain & Jumadi, 2018). While other learning models such as project-based learning (Sumarni & Kadarwati, 2020), FERA learning (Diani *et al*., 2020) on the KBK-KL indicator did not reach the target. Thus, the learning model is not yet fully optimal to develop KBK-KL,

Not optimizing various learning models to improve KBK-KL due to several obstacles. The obstacles are divided into three main problems. First, learners are still experiencing difficulty in connecting the theory that has been studied with the problem at hand (Sumarni & Kadarwati, 2020). Second, the differences in critical thinking abilities are influenced by the initial abilities possessed by each student (Herunata *et al*., 2020). Third, students find it difficult to do the given test, this is because it is not only solved by mathematical equations, but requires an explanation based on scientific reasoning abilities. (Pradana & Parno, 2017; Sumarni & Kadarwati, 2020; Herunata *et al*., 2020; Herawati *et al*., 2020).

While the suggestions include 1) authentic problems containing puzzles and activities Hypothesis and experimental activities can improve critical thinking ability on advanced clarification components (Mundilarto & Ismoyo, 2017; Kadarwati 2020; Rahmi *et al*., 2019; Diani *et al*., 2020).2) multiple representations help improve critical thinking skills in the clarification component further (Herawati *et al*., 2020).3) Optimizing practice and guidance in working on thinking tests(Diani *et al*., 2020; Herunata *et al*., 2020) and strengthening reasoning (Pradana & Parno, 2017; Sumarni & Kadarwati, 2020; Herunata *et al*., 2020; Herawati *et al*., 2020).Constraints and input from the results of this study will be part of developing the model.

Based on the analysis of the research results, so that the KBK-KL can be increased, what the researchers did was strengthening reasoning, and optimizing training and guidance. Strengthening reasoning is done through making learning assignments. While optimizing the exercise is to give practice questions and conduct dialogue to students to control the achievement of KBK-KL.

E. The Inquiry Learning Model and Its Contribution to the Development of KBK-KL

1. The Importance of Inquiry Learning in Basic Physics CPMK

One of the courses contained in the curriculum of the Informatics Education Study Program is Basic Physics.The description of the Basic Physics course is to provide an understanding of the basic concepts of engineering physics which include the quantities and units of each object, vectors, kinematics and dynamics of work and energy objects, and mechanics.

Physics courses in the Informatics Education Study Program curriculum include types of:subject mandatory which aims to be part of the sequence subject which forms one of the supporting competencies such as the Robotics course. These supporting competencies will then contribute to the formation of the main competencies in accordance with the concentration of the field chosen by the students of the Informatics Education Study Program. Therefore, this Basic Physics course is held in the early semesters because it is a subject prerequisite for the formation of these supporting competencies.

Based on the curriculum at the Trunojoyo University Informatics Education Study Program, Madura, the Basic Physics course has an identity as shown in Table 2.4.

Table 2.4 Identity Subject Basic Physics

NO	Identity	Information
1.	Type of Course	Compulsory Informatics Education Study Program
2.	Course Code	PIN 235
3.	credits	3 credits
4.	Course Learning Outcomes (CPMK)	Describe the basic concepts of physics to develop its application in the field of informatics
5	Course Description	Provide an understanding of the basic concepts of engineering physics which includes the quantities and units of each object, vector, kinematics and dynamics of work and energy, and mechanics
6	Scope of Study	a. Physics Concepts in Informatics b. Quantity and units c. Vector d. Kinematics e. Work and Energy f. Collisions and Momentum

Based on Table 2.4 CPMKBasic Physics describe the basic concepts of physics to develop its application in the field of informatics. Reinforced in the description of basic physics courses equip an understanding of the basic concepts of engineering physics which includes the quantities and units of each object,vector, kinematics and dynamics of work and energy objects, and mechanics.Among the appropriate learning models to train the right science to prepare students for the 21st century, including problem-based learning, project-based learning, and inquiry learning (Scott, 2015; Dewi, 2020), the inquiry learning model is very appropriate because it has a goal to supply of concept mastery (Arend, 2008,Duke, 1990).

The inquiry learning model is a form of learning to build concepts (Arend, 2008; Duke, 1990). The inquiry model can be applied to various subjects (Duke, 19906; Blessinger & Carfora, 2015). This was also stated byArend, (2008) that the inquiry learning model can be applied to social science neuroscience. The inquiry learning model is very relevant to the scientific principle that natural science knowledge is revisionary, i.e., knowledge in science is not absolute or can be restructured based on the latest data (Joyce *et al*., 2009). The basic concepts of the phenomena studied by science can be obtained through experimental activities contained in the principles of inquiry learning (Slavin, 2011).

The essence of teaching science by inquiry is to draw conclusions through a process and will continue to be tested for truth. This learning needs to bring up students' ideas to test the truth, experiment as a form of testing the truth, show data and interpret thus finding scientific knowledge (Joyce *et al*., 2009). Duke, (1990) also has the same view that the concept is obtained from the process of hypothesis, testing hypotheses through experimentation, this is the main basis in studying science. Likewise, Slavin, (2011) the application of the inquiry model seeks to learn like scientists, the knowledge process is obtained through a process not a product. So that inquiry learning is not from the transfer of information but through the process of investigation or experimentation.

2. Study the Inquiry Learning Model

In general, the inquiry learning model contains five important features for learners: (1) is engaged by scientifically oriented questions, (2) prioritizes evidence, (3) formulates explanations from evidence, (4) evaluates their explanations in alternative explanations, and (5) communicating to other friends (Council National Research, 2000).Information related to the inquiry learning model is discussed by (Arend, 2008; Joyce *et al.*, 2009), therefore these two ideas become a reference in developing learning models.

Arend, 2008). There are five stages in the inquiry learning process, namely: (1) providing problem situations and explaining inquiry procedures to students. Thought-oriented questions, although simple, can be: puzzles, magic tricks or activities other, (2) students verification can be in the form of the nature of the object or the situation of the problem, (3) making hypotheses and carrying out data collection activities, (4) organizing data, and formulating to make explanations, and (5) analysis of investigative strategies, namely carrying out the process of evaluating the inquiry process that has been carried out.

The inquiry model fulfills the elements of a model including the social system, reaction principle, support system and impact instructional (Joyce *et al.*, 2009). Social system, learning model inquiry requires an open intellectual, meaning that everyone has the right to have ideas. In this model, there will be teacher-student interaction activities, as well as between students and others in the context of generating ideas or ideas. The principle of reaction is in the second phase when a teacher provides feedback to students regarding several questions such as possible variables that may affect the problem presented. And in the fifth phase when asking students to evaluate the inquiry process that has been carried out.

The support system, i.e., the teacher must understand device learning materials such as material, possible answers provided during the learning process to deal with problems. Through mastery of learning tools all problems faced by students will be easily solved. Educators will easily provide certain suggestions or directions so that each participant can meet the set targets. Instructional impact, through learning activities that optimize the process of investigation and discussion this will affect the achievement concept understanding.

Things that need to be considered in planning the inquiry learning model are determining goals and identifying problems (Arend, 2008). Joyce *et al*., (2009) need to investigate the concept of the real problem, and it is necessary to identify the problem including the conceptual and methodological problems. Problems must be able to arouse feelings of wanting to know and learning motivation (Slavin, 2011; Arend, 2008). Specifically, Arend, (2008). provide three criteria in formulating the problem, namely: 1) contains rich conceptual and inquiry processes that can be carried out, 2) flexible to developments, and 3) relevant in daily life.

There are obstacles in the implementation of the inquiry learning model that need to be considered in research, namely aspects of psychology in process setting learning. Psychologically, the inquiry model makes it easy for students to be frustrated because it is not ready in the process of scientific investigation (Duke, 1990). The inquiry model takes a lot longer time than conventional learning (Binns

& Popp, 2013). So, it is important for educators to do good time management while in the classroom.

Students who are given free inquiry learning (open inquiry) are not effective in learning (Arend, 2008), even errors occur and waste a lot of time (Slavin, 2011). So it is necessary to design learning that is oriented towards active thinking with sufficient guidance (Arend, 2008; Slavin, 2011). Arend, (2008) argues that guidance is given based on the initial abilities possessed by students, while Slavin, (2011) technically provides instructions in learning activities and provides only outlines.

Based on the opinion of experts, it can be concluded that an important basis in planning the inquiry learning model is to identify problems that can be carried out by the inquiry process, not answer-oriented problems without an investigation process. In order for inquiry learning to be effective, providing sufficient guidance is important by considering initial abilities and providing instructions and outlines to be of concern to students. The basic principles of inquiry will serve as a reference in the model development plan to improve KBK-KL.

3. Contribution of Inquiry Learning Model to Critical Thinking Ability

The inquiry learning model is one of the learning models to train the thinking skills of students (Arend, 2008). Critical thinking skills can be trained through inquiry learning that applies the principle that students need to solve problems that begin with questions through an investigation (Suchman, 1968). As stated by Duke (1990) the inquiry learning model was developed not asking for an answer to a question, but aiming to familiarize students with revealing answers through the interpretation of data obtained through investigation.

The contribution of the inquiry learning model in improving critical thinking skills can be applied in the field of science. The field of science in question is three branches of science, namely biology, chemistry and physics. In order to be more detailed, each branch of science is separated based on its level, namely at the elementary level (SD and SMP), junior high school and high school (SMA/SMK), and tertiary education levels. The process of reviewing the research results starts from a search based on the field of science then will describe the contribution of the inquiry model to critical thinking skills based on education level.

The inquiry learning model measures critical thinking skills in the field of biology. At the junior high school level, research has been carried out by applying inquiry learning (Hwang & Chen, 2017; Fuad *et al*. 2017; Makmur *et al*., 2019; Rahmi *et al*., 2019; Pursitasari *et al*. 2020). The level of higher education has been researched by Greenwald and Quitadamo (2014) with research subjects of biology students with neuroanatomical material, and Muskita *et al*., (2020) by providing graded worksheets. Both at the high school and higher education levels, the inquiry learning model can improve critical thinking skills.

In the field of chemistry, research has been carried out at the high school level by applying inquiry learning (Wardani, Lindawati, & Kusuma, 2017, Jainal and Yosephine Louise 2019, and Farah & Ayoubi 2020) and at the vocational high school level (Herawati *et al*., 2020). While at the level of higher education research (Gupta *et al*. 2015; Alkan, 2018; Sonmez *et al*., 2020). In the field of chemistry both at the high school and college level, it can be concluded that the inquiry learning model can improve critical thinking skills.

In the field of physics, at the high school level, research has been carried out by applying inquiry learning (Zain and Jumadi, 2018; Maknun 2020; Yuliska & Syafriani, 2019). At the tertiary level (Irwanto *et al*. 2019; Prayogi & Verawati, 2020). Both at the high school and higher education levels, the inquiry model has been shown to have an effect on critical thinking skills.

Especially for the KBK-KL indicators, the inquiry learning model has not shown consistent results. Some researchers of the inquiry model on measuring critical thinking ability on advanced clarification can meet the standards set (Maknun, 2020; Rahmi *et al*., 2019). On the other hand, the inquiry model has not been fully optimized to improve critical thinking ability on advanced clarification (Irwanto *et al*., 2018; Zain & Jumadi, 2018; Herawati *et al*., 2020; Pursitasari *et al*., 2020). The majority of the inquiry model is not optimal in achieving advanced clarification critical thinking skills. Inquiry learning has not been consistent in achieving the KBK-KL target, it is necessary to improve the learning design in order to obtain consistent KBK-KL results.

The measurement of critical thinking ability on advanced clarification which is applied using the inquiry learning model is shown in Table 2.2. The sign (V) indicates the indicator under study while (X) indicates the indicator that is not studied. These seven indicators are the development of the latest version of the critical thinking ability component for advanced clarification (Ennis, 2016).

Table 2.5. Research Analysis of Inquiry Learning Models Based on KBK-KL Indikator Indicators

No	Researcher	Advanced clarification indicators						
		1	**2**	**3**	**4**	**5**	**6**	**7**
1.	Irwanto *et al*., (2018)							
2.	Zain & Jumadi, (2018)							
3.	Rahmi *et al*., (2019)							
4.	Herawati *et al*., (2020)							
5.	Maknun, (2020)							
6.	Pursitasari *et al*., (2020)							
Dissertation Research								

Information:1. Assess phenomena based on appropriate criteria; 2. Evaluating a person's line of thought; 3. Identify unstated assumptions; 4. Predictive thinking; 5. Handling label errors; 6. Metacognitive thinking; and 7. Solve problems sequentially.

Based on Table 2.5 the measurement of critical thinking skills in various studies only includes two indicators, firstly assessing the definition based on the right criteria (Irwanto *et al*., 2018; Zain & Jumadi, 2018; Rahmi *et al*., 2019; Herawati *et al*., 2020; Maknun, 2020; Pursitasari *et al*., 2020). The second indicator is identifying unstated assumptions (Irwanto *et al*., 2018; Herawati *et al*., 2020; Maknun, 2020; and Pursitasari *et al*., 2020). This is because the initial version of the KBK-KL only contained two indicators assessing phenomena based on criteria and identifying assumptions (Ennis, 1985a). So that researchers tend to only measure on these two indicators.

Thus, the inquiry learning model has never been used to develop the seven KBK-KL indicators simultaneously. This study will develop a learning model to train the seven KBK-KL indicators which include 1). Assess phenomena based on appropriate criteria; 2). Evaluating a person's line of thought; 3). Identify unstated assumptions; 4). Predictive thinking; 5). Handle label errors; 6). Metacognitive thinking; and 7). Solving problems in order

F. Work and Energy Subjects and Measurement of KBK-KL

1. Work and Energy Subject

Basic physics aims to equip students in mastering the basic concepts of physics as a condition for taking robotics courses. The main topics in the Basic Physics course include: quantities and units, vectors, kinematics and dynamics of matter, work and energy, and mechanics. Work and energy were chosen as research subjects for the development of KBK-KL. This is due to work and energy being abstract, physical changes in energy can be seen but the value is abstract so the concept of energy requires critical thinking skills (Hill, 2008). The distribution of KBK-KL on the subject of Work and Energy is shown in Table 2.6.

Table 2.6 KBK-KL Indicators on Work and Energy

No	Study Material	Indicator of Advanced Clarification Critical Thinking Ability
1	Basic Work Concept	Assess phenomena based on appropriate concepts Evaluating the flow of thought somebody Identify unstated assumptions.
2	Work Relationship with Energy	Predictive thinking. Handling label errors
3	Mechanical Energy	Think metacognitively. Complete Work in order

Based on Table 2.6, the seven KBK-KL indicators are not directly taught in one study material but are divided into various study materials; it is hoped that KBK-KL will be mastered by students. In order for work and energy learning to be more optimal, it is necessary to examine various relevant studies. The results of the research become an important input to achieve an increase in the quality of learning.

The results of the study show that it is still found that many students define the concept of energy as a material that has the potential to be able to move something (Bächtold, 2018). Thus, it is necessary to build the concept that energy is abstract (Jewett, 2010), which has implications for all activities of living things. So that the understanding of energy is not limited to changes in motion but changes in energy include many things, motion is a form of energy use (Abdullah, 2016). Each student can understand the factors that can affect the energy of an object. The use and change of energy can be exemplified by an event that a candle can light up, where there is a change in chemical energy into heat (Bächtold, 2018).

The subject matter discussed in energy includes gravitational potential energy, kinetic energy in work which is usually difficult to separate so that it is included in the law of conservation of mechanical energy. Another study by Warren & Richmond (2018) study of work and energy is still limited to ideal systems, without mentioning a decrease in energy. Suggestions in this study need to design the learning process by linking experience, besides that it is necessary to consider simple language so that it is easily understood by students.

Energy learning becomes more meaningful if students are asked to analyze concepts whose themes are still mastered with the help of an advanced organizer

(Gidena & Gebeyehu, 2017). Because basically studying the matter of work and energy will be related to the concepts contained in Newton's laws related to motion (Giancholi, 1997). It is even more interesting when the phenomenon is faced with events experienced by students (Saputro, Tukiran, *et al*., 2020).

In studying energy, try to get students to make predictions, so that students can carry out scientific activities through experiments, which are further strengthened by linking them in everyday life. By making predictions students will know the level of truth or error of concepts that have been predicted through scientific experiment activities (Papadouris *et al*., 2014). So that future learning is not only on quantitative calculations in answering questions, but also must be able to answer why energy is needed in everyday life.

Based on empirical facts, the important points in learning physics on work and energy materials include (1) learning must be able to present reality or actual conditions, (2) need to implement concepts through variable manipulation activities in order to get meaningful concepts, (3) need to strengthen reasoning power as basis for decision making, (4) it is necessary to optimize multiple representations in order to obtain maximum results, and (5) it is necessary to relate the material learned to its application in everyday life.

2. KBK-KL Pengukuran Measurement

Measurement of critical thinking skills can be done using a test instrument. So, we need to analyze the elements of the critical thinking ability test. Based on the example of the critical thinking ability test developed by Ennis, there are 2 things that are important to be the basis for its development, namely the determination of indicators and the form of the test (Ennis, 1985a; 1985b).

Determination of indicators is the basis for developing critical thinking ability tests by limiting the scope of making questions. Coverage of indicators measured in the regionConnecticutand California include basic clarification, conclusion, clarity and problem solving (Ennis, 1985a). The development of an open-ended essay test Ennis also lists the abilities to be measured such as considering definitions based on criteria, seeing one's reasons and assumptions, dealing with misunderstandings by providing rational reasons, seeing other possibilities, responding appropriately to false claims (Ennis, 1985b).

The results of initial thinking about critical thinking skills consist of several components, namely basic clarification, basic conclusions, conclusions, advanced clarification, strategies and tactics (Ennis, 1985a). Based on two examples of test development, indicators developed by Ennis, show that researchers only take some indicators, this is inseparable from the research objectives and research limitations. For example, to make a type of test in an area that has a large coverageConnecticutand California then more precisely the development of tests that do not measure evaluative ability (Ennis, 1985a). It is different for the purpose of high school and higher education to measure evaluative ability so that the indicators are taken in the advanced clarification component (Ennis, 1985b).

This is confirmed by several research results. The critical thinking ability test developed by the researcher Ennis determines different indicators. StudyDanday & Monterola (2013) measure on indicators conclusion, identification of assumptions, deductive reasoning, explanation and evaluation of arguments, while the research of Sumarni & Kadarwati (2020) measures the indicators of basic clarification, the basis for concluding, concluding and advanced clarification. The test using Facione's critical thinking ability indicator also shows differences in the indicators of each researcher. Study Isnawati *et al*., (2020) measuring indicators conclude, evaluate, analyze, and interpret, while research is interpretation, analysis, evaluation, conclusion and explanation.

Based on the analysis of the sample indicators developed by Ennis, strengthened by the results of the study and considering the research objectives, the researchers determined seven KBK-KL indicators. The indicators measured include:1). Assess phenomena based on appropriate criteria; 2). Evaluating a person's line of thought; 3). Identify unstated assumptions; 4). Predictive thinking; 5). Handle label errors; 6). Metacognitive thinking; and 7). Solving problems in order.

The second isoform of critical thinking test, there are four types of test forms in critical thinking measurement, namely multiple choice, essay or mixed multiple choice accompanied by a brief description, and performance appraisal (Ennis, 1985a; 1985b; 1993; Ennis *et al*., 1964). Testing the form of multiple choice, namely by asking questions that contain information or a certain condition, then there is a statement that each student is asked to choose three (3) options, namely justifying by choosing (yes), blaming by choosing (no), or choosing (maybe), if the answer is not in either position (Ennis *et al*., 1964).

The sample questions were taken in The Cornell Conditional-Reasoning Test, Form X, question number 3.

> Suppose you know that
> Jane standing by Betsy
> Question
> Is it true that it is best to stand near Jane?
> Answer
> a. Right
> b. Wrong
> c. Possible

TypeThis test is very suitable for measurements in scale big as done in the region Californiaand Connectitude (Ennis, 1985a). There are several notes related to multiple choice tests, including 1) multiple choice tests are less comprehensive, 2) multiple choice tests are not effective in testing important aspects of critical thinking, such as freedom of thought and caution in drawing conclusions, 3) multiple choice tests do not facilitate background behind question maker with the background of students, and 4) choice testdouble often leads to compromise

Essay or open-ended test (Ennis, 1985b; 1993). The purpose of making essay tests is to facilitate students to assess an argument and formulate arguments to answer the questions that have been given. Ennis, (1993) displaythat essay tests facilitate students to think openly, based on how to answer questions will be interpreted based on predetermined criteria. Open answers include a creative dimension (Ennis, 1985a). Not much different from the multiple-choice test, the essay test also begins with the presence of certain information or conditions that must be responded to by the informant taking the test (Ennis, 1985a). The sample questions are taken in The Ennis-Weir Critical Thinking Essay Test question number 5 as follows:

> A condition
> If parking is prohibited from 2am to 6am, then accidents between parked and moving vehicles will be eliminated. Any intelligent citizen would find eliminating accidents to be desirable for everyone. So, we have to support the parking ban from 2am to 6am
> How to answer
> In this test, a complex argument is presented to the test taker, the test taker is asked to give the correct argument for each information or condition that has been presented.

Multiple choice test with short description, Ennis has developed Cornell CriticalThinkingThe test, Level X, was multiple choice and asked for a brief written justification of students' answers to each item (Ennis *et al*., 1964). One advantage of this promising short multiple-choice format is that certain aspects of critical thinking can be covered such as careful choice of answers (Ennis, 1993). Test evaluation erformance is an assessment based on a real event situation, every activity carried out by students will be reported and given an assessment usually in the form of a portfolio (Ennis, 2008).

Based on the variety of critical thinking measurements that have been described, both essay tests and multiple choice have the same characteristics, namely the test contains certain information or conditions, questions in the form of responses to analytical skills to get the appropriate answer. This format will be used as the basis for developing critical thinking test questions in the advanced clarification component. An example of the test format that Ennis developed would be customized into making questions in the domain of physics.

The form of the test in the form of an essay was chosen for the research plan. This is because the test in the form of an essay can facilitate critical thinking, test takers can decide the answer after weighing various information or knowledge previously possessed.so that also showed caution in determining answers (Ennis, 1985b). Open-mindedness is highly correlated with assessing source credibility and identifying assumptions (Ennis, 1993), this is in accordance with advanced clarification indicators as a basis for measurement, namely assessing statements based on assumptions and deduction processes (Ennis, 2016). Different from the type of multiple choice which is able to facilitate measurement in a wide range (Ennis, 1993), the quantity measurement plan is not too large, namely to test the experimental class and control class so that it is still possible to evaluate the source.

The selection of essay tests is in accordance with empirical facts that convey the benefits of the essay test form, namely providing more opportunities to express students' thinking strategies. Written test questions can stimulate important aspects of critical thinking, namely analyzing, rethinking, or generating new ideas (Franco, Costa, and Almeida, 2018; Franco *et al*., 2018; Tiruneh *et al*., 2017; Asmawati *et al*., 2018). Reinforced by the results of a literature study conducted by (Saputro, Tukiran, *et al*., 2020) the basic principles of making critical thinking test instruments include presenting phenomena, open tests, and testing rationality.

G. Learning Theory for Critical Thinking Development

Learning to practice critical thinking skills requires special designs with various forms of activities, such as analyzing, comparing and other activities

(Stephen Johnson; Harvey Siegel, 2010). This opinion is reinforced by McPeck (2017), namely the ability to think critically is a skill, so it can be taught through a certain training. Critical thinkers only provide signs for teaching critical thinking skills in general, namely learning can be done through a problem-solving process (Ennis, 2015; Facione & Gitten, 2016).

Physics is a part of natural science that discusses natural phenomena that have an impact as a science that builds critical thinking and investigation methods (Koballa, 2010). The concept of physics can be obtained through analytical and observational approaches. Physical products are the result of processes in the form of: facts, concepts, principles, theories, and laws (Ibrahim, 2012). Learning concepts based on the reality that is around us will have an impact on future readiness (Bueche & Hecht, 2006). In addition, through mastery of concepts it can be applied for various purposes, through: manipulation or material manipulation through creative ideas (Suyido, *et al*., 2020). Thus, the right theory is needed to train critical thinking skills in Basic Physics courses, including constructivist theory, intellectual development, discovery learning, learning mean, social constructivism, and metacognition theory.

The first constructivist theory, this theory contains that students must build their own knowledge individually and collectively. Knowledge can be built based on the concepts you have, both obtained through observation and information previously (Lunenburg, 2011). If facts, information, experience, moral values cannot be mutually reinforcing, there are two possibilities that students will reject the information or retain information (Baviskar *et al*., 2009). The most appropriate thing to form orconstructknowledgethroughnew events (Ray, 2002). So Expensive activityinvolvingactivityCognitive skills such as discussion, analysis of facts can form a concept of knowledge (Chang, 2005).

The role of the educator is to choose an activity which can buildactivity cognitively, like asking an event. For students who do not have an initial concept, it can be given guidance, modeling behavior and simple examples (Lunenburg, 2011). Because this learning experience is personal and has a schema, it needs giving experience in order to form the scheme that we hope to achieve (Ray, 2002). And the most important thing is that students participate in cognitive activities such as analysis, interpretation, inference and sharing experiences with their friends.

SecondThe theory of intellectual development, this theory was put forward by Jean Piaget, namely that in general everyone experiences cognitive development in stages. These stages include sensorimotor, preoperational, concrete operations and formal operations. Students are included in the formal operational category so that they are able to be involved in solving abstract problems (Slavin, 2011; Arend, 2008). Piag*et al*so provides a theory to understand a person in adapting their environment through the process of assimilation and accommodation. Every given phenomenon will be responded to through organizing the knowledge that has been possessed (schemata) which is called assimilation. If they are not able to match the new data or situation to the existing schemata, they must develop a new concept or schemata called accommodation (Arend, 2003). 2008; Moreno, 2010).

The process between assimilation and accommodation tends to be natural which is driven to find equilibrium or balance (Moreno, 2010). Knowledge is not static and will continue to grow and change because students experience new experiences and force them to modify knowledge independently (Arend, 2008). Students can ask questions, and make efforts to find answers by matching what they have found with their predictions, comparing their findings with the findings of other friends (Arend, 2008).

Thirdtheorydiscovery learning by Jerome Bruner. Each concept is not the result of giving but needs to be discovered by students (Moreno, 2010). The conceptualization of one's way of learning according to one's maturity level consists of 1) learning by doing, 2) learning by forming mental images, called iconic modes and 3) learning through a series of symbols or abstract representations called symbolic methods (Arend, 2008). The impact of the way of learning will lead to discovery learning, learning design must be able to increase activity and be involved in the learning process (Slavin, 2011). This is because true learning is caused by personal discovery. The emphasis on learning needs to emphasize inductive reasoning and the process of inquiry (Arend, 2008; Slavin, 2011).

The four theories of social constructivism that emphasize the importance of the Zone of Proximal Development (ZPD) developed by Lev. Vygotsky. The main emphasis in this theory lies in the importance of social and cultural interactions in learning (Moreno, 2010). Social interaction will spur the development of new ideas and enhance intellectual development (Arend, 2008; and Slavin, 2011). This theory states that learners have different levels of learning, starting from the level of actual development and continuing to the level of potential development. The actual level of development is when students are able to learn things independently, while the level of potential development of social interaction with groups and the longer it will lead to problem solving independently (Tomei, 2010).

Fifth Meaningful learning theory. which was developed by Anderson, Ausubel and Gagne, namely students can connect new information with previous knowledge that exists in themselves (Moreno, 2010; and Tomei, 2010). The purpose of the meaningful learning method is to expand the original information by associating new information with other information stored in long-term memory (Moreno, 2010; Slavin, 2011). The method used is the elaboration method, where students use previous knowledge to expand a new idea. While the organization provides an orderly structure on pieces of information to create visuals of all concepts, for example by making concept maps.

Sixth Metacognition theory, this theory comes from two words, namely meta and cognition, the prefix of the word meta comes from the Greek language which means about while cognition is knowing. So that metacognition can be interpreted as an individual's cognition about his own cognition (Moreno, 2010; Tomei, 2010). Arend, (2008) asserts that metacognition is more about monitoring and regulating their own learning. Teachers can model metacognition and self-regulation by helping students set specific goals for themselves and asking students to keep records of their performance and reflect on their learning in journals or portfolios (Moreno, 20107).

H. Study of Student Characteristics

1. Student As Adult Student

Students are adults, therefore, as lecturers, they must know their character. First, the theory of cognitive development developed by Piaget for someone who is 11 years olduntilAdults are classified as formal operations, namely having abstract thinking, being able to hypothesize and being able to solve problems with symbolic experimentation (Slavin, 2011). Moreno, (2010) has the same opinion by describing in more detail related to formal operational abilities, namely the ability to hypothesize or predict through controlling variables. This ability is used for scientific discoveries for someone who has entered adolescence and adulthood. They are able to discuss and willing to receive knowledge based on reasons and evidence (Upton & Trapp, 2010; Slavin, 2011). Thus, students have the ability to think abstractly, hypothesize, and can solve problems with experimentation and can accept knowledge based on reason and evidence.

Second, the social theory developed by Ericson, someone who is 18-22 years old is included in the adult category and has developed in the achievement of identity, they can make their own decisions with full awareness (Slavin, 20110). Moreno (2010) agrees that adults are required to be able to make personal and professional life decisions. Even Garry *et al*., (2013:58) argue that adults want to be involved in decision making. This is reinforced by Tomei, (2010) adults want to play a role in groups in solving problems. Thus, students want to be involved in decision making and can't make decisions independently.

Third, adults tend to have experience which is quite caused by the long experience that has been passed (Garry *et al*., 2013). The same view is held by Tomei, (2010) adults have an initial concept, this is due to the process of experience and problems that have been passed. The initial concept has an impact on the ability of adults in self-direction (Henschke, 2009). So that they are able to determine understanding related to the material individually (Moreno, 20107). But what needs to be noted is that the initial concept level of each adult is different, this is based on their different life experiences (Tomei, 2010). Thus, students already have an initial concept of knowledge caused by the life experiences they have passed. However, the depth of concept varies, so group learning is needed.

Adult learners tend to like to socialize and cooperate and are sensitive tocharacteristicshis group (Garry *et al*., 2013). Slavin, (2011) also said that adults have good friendships, respectselfhigh and social needs. Tomei, (2010) revealed the theory developed by Ericson concluded that social interaction between students and society is the need of every individual, and has an impa ct on the development of cognitive adult learners. Harris & Cullen, (2010) design an education in order to run well it is necessary to pay attention to the picture of a human life. The main subject in education is human, so to be the best teacher one must be able to understand the human condition. Thus, students want to have the opportunity to interact well with their friends or public.

Based on the opinion of experts, it can be concluded that students are included in the adult category which has the following characteristics: (1) students have the ability to think abstract, hypothesize, and can solve problems with experimentation symbolic, can accept knowledge based on reason and evidence; (2) students want to be involved in decision making and can't make decisions independently; (3) students already have an initial concept of knowledge caused by the life experiences they have gone through; and (4) students want to have the opportunity to interact well with their friends or public. Student factors as adult learners will be considered in the development of learning models.

2. Students Including Generation Z

Interaction between humans with various conditions produces many definitions with different characters called generations (Seemiller & Grace, 2016; Strauss, 2007). The current condition of students can be categorized as generation Z, because they were born from 1995 to around 2010 (Seemiller & Grace, 2016). Generation Z is usually referred to as digital native, the net generation, or I generation. Generation Z is alive in nature, reality and virtual coexistence with high technology, smart, efficient (Seemiller & Grace, 2016; Wood 2013). The technology is used to solve the problems and challenges of the times. Geck (2006) stated that this generation will be the most enthusiastic generation in using various technological equipment. Thus, generation Z students place technology as an inseparable part of their lives to solve the problems they face.

Digital technology is indeed the main characteristic of Gen Z, but they also still want an authentic relationship with other people (Seemiller & Grace, 2016). Generation Z is more communication active to care about others (Barreiro & Bozutti, 2017). Another thing that their communication needs to understand is that they are familiar with text messages rather than verbally, and like to use non-verbal symbols (Carter, 2018). He naturally likes to be cared for by others who showed through communication (Miller, 2019).

The results of Yu's research (2016) state that the communication character of Generation Z students is caring, namely caring about the lives of others and respecting people who care about them so that it has a high impact on solidarity. In addition, it shows an open attitude to anyone, and wants interaction in a communication pattern or not one-way communication, which is ready to accept all ideas and want to be heard every time (Seemiller & Grace, 2016; Fernández & Fernández, 2016). Thus, students want an interactive pattern of communication, and they want an element of communication concerning each other in life.

In the context of learning, Generation Z wants learning that is based on logic and existence experience, so it can be used for problem solving (Seemiller & Grace, 2016). Generation Z students are very realistic. What they learn must have an impact on benefits in the world of work. They want to apply the theory they already have to solve problems in the real world (Seemiller & Grace, 2016; Purcell & Purcell, 2019). Thus, it should be noted that student motivation is based on the aspect of profit in the career world.

Based on the opinions of experts and reinforced by research results, it can be concluded that generation Z or the digital native generation, the net generation, or I generation have the characteristics of (1) using technology as part of solving the problems they face; (2) care about other people's lives and respect for people who care about them which has an impact on high solidarity (3) students are ready to hear every idea and idea and want to be noticed for their ideas and ideas (4) students are realistic, namely learning motivation based on the principle of usefulness for support career. Student factors as Gen Z will be considered in the development of learning models

I. Distance Learning.

The environment in the development of learning models is an important factor determining the success of the goals set (Aunurahman, 2009). The current condition of the classroom and environment does not allow face-to-face meetings due to the Covid 19 pandemic. So, distance learning is an important thing to study. The basis of distance learning is based on a circular by the government through the Ministry of Education and Culture number 1 of 2020 concerning Prevention of Spread *Coronavirus Disease* (Covid-19) College (Directorate General of Higher Education, 2020). Study distance learning includes the definition of distance learning, and the important factors of distance learning.

1. Definition of Distance Learning

Distance learning is a form of learning between educators and students who are geographically in separate places, the nature and scope of which is mediated by various media and technologies (Jung & Richter, 2019; Sewart, 2014). The forms of media in distance learning vary according to technological developments, ranging from posts, radio TV and interactive videos (Jung & Richter, 2019; Kentnor, 2015; Moore & Kearsley, 2012).

Likewise, Hartnett (2016) distance learning is learning mediated by technology because of the difference in positions between educators and students, the technology is used for interaction between students and educators to gain knowledge, build meaning and learning experiences. Even with technological advances apart from being separated by place, there is a time difference between educators and students (Anjana, 2018). Philosophically distance learning has the principle of "learning anywhere and anytime"(Bork & Gunnarsdottir, 2001).

The form of distance learning can be done with online learning (Hartnett, 2016). Or with other terms that are often used in distance learning, namely electronic learning or e-learning (Jung & Richter, 2019; Bork & Gunnarsdottir, 2001). Distance learning can be done online synchronous namely the existence of students and teachers being in a virtual space together or streaming, able asynchronous that is, teachers and students are not in one virtual space (Skylar, 2009).

Based on the opinion of experts, it can be concluded that distance learning is a form of learning between educators and students who are geographically in separate places, the nature and scope of which is mediated by various media and technologies to build knowledge, meaningful learning and learning experiences. The term distance learning includes online learning, e-learning with various information technology platforms that can be done online synchronously (both teachers and students are both online and offline) *asynchronous* i.e. teachers and learners are not in direct contact in the online learning platform. The development of the learning model will use the approach *synchronous* and a*synchronous*.

2. Important Factors of Distance Learning

During the distance learning pandemic mediated by various information technology platforms, educators need to be prepared to master the technology (Agormedah *et al*., 2020; Mishra *et al*., 2020). The impact of changing face-to-face learning to distance learning has not been able to run optimally (Dew *et al*., 2020; Hidayat & Wibawa, 2020). Therefore, it is necessary to pay attention to important factors so that distance learning can run optimally.

First, distance learning needs to optimize motivation. Jung & Richter (2019) argues that so that students have the initiative to learn independently in the implementation of distance learning, various guides can be in the form of video tutorials or books equipped with detailed instructions. So is the opinionHartnett (2016) and Anjana (2018) The essence of distance learning is being able to optimize participants' learning motivation educate, so that motivation can run optimally, it is necessary to touch the character and personality of students. Bork & Gunnarsdottir (2001) have the same opinion that distance learning should optimize individual learning motivation.

The opinion of experts regarding the importance of motivation in distance learning is supported by empirical facts in the form of research results. Hidayat & Authority Research (2020) suggested that the communication pattern built in distance learning needs to foster student motivation and interest in learning. So asAli (2020) online learning during a pandemic is an additional learning space, so students need to optimize learning independently. However, building learning motivation in online learning is not an easy activity; from the results of research, many students experience a decline in doing assignments independently (Dew *et al*., 2020; Agormedah *et al*., 2020).

Role of educator need to have a paradigm as a facilitator in learning (Danjou, 2020). So that students can learn organic chemistry independently, researchers design learning apart from meetingsbyonline, lecturers also provide material and assignments in the form of documents in the form of files or videos on*Facebook*. Giving materials and assignments is liked by students because they can learn and do assignments at their own paceAljanazrah, (2020). So that independent learning requires very clear and detailed materials, one of which is providing video content for the experimental learning process in a simulation.

Second, the use of technology in distance learning needs to be oriented towards learning objectives and social interaction. This was stated byJung & Richter (2019:119) interactions during the distance learning process should all have clear goals, especially to achieve learning goals. Bork & Gunnarsdottir (2001)argues that all activities and interactions in learning distance far needs to be developed a module that contains multimedia interactive. This is reinforced by Hartnett, (2016) states that the interaction between educators and students aims for students to gain knowledge, build meaning and have learning experiences.

Interaction in online learning can be asynchronous, namely through discussion forums available on information technology platforms, or synchronously, namely during video conference activities, or streaming. (Skylar, 2009). Application of both synchronous *and* asynchronous methods is ideal because each student has a different learning speed (Offir & Bezalel, 2008). Thus, the role of interaction in distance learning should be prioritized to maintain the quality of learning. Educators need to open up to students if they experience difficulties while learning.

Related researchoptimizationInformation technology, based on the results of distance learning research through online face-to-face activities, is able to maintain the quality of learning and social interaction (Danjou, 2020). This is reinforced by the research of Pratama *et al*., (2020) concluded that the existence of learning facilities both face-to-face and online was able to facilitate interaction and communication effectively towards learning objectives. Way of communication *synchronous* favored by handling trainee injury bone (Rodrigues *et al*., 2020). In virtual face-to-face learning, it is necessary to present social nuances, namely by mentioning the names of students, and cognitive presence through polling techniques or quizzes are like cutting content to keep students focused in class (Reinholz *et al*., 2020).

The availability of a Learning Management System (LMS) can be optimized to provide material content, detect capabilities, measure and organize goals (Hoq, 2020). Student involvement in activities learning online is a determinant of success in learning (Baber, 2020). Even through information technology experiment who are accustomed to real conditions, can be simulated through experiments virtually (Hashemipour *et al*., 2011). Practice By Virtual reality can reduce fear if something goes wrong (Onal & Onal, 2020).

Third is the importance of implementing a comfortable and friendly atmosphere. According to Jung & Richter (2019: 5), distance learning also needs to pay attention to the differences in the backgrounds of the students, both cultural and socio-economic. Likewise, Bork & Gunnarsdottir (2001:104) argue that being a teacher must have a friendly and non-judgmental attitude to be able to provide assistance when there are problems in mastering the material and continue to provide motivation. This is reinforced by Anjana (2018) providing services to students in distance learning is a very important factor because they often have obstacles or problems. Similar to Bork & Gunnarsdottir, (2001) students need services to support communication according to their needs.

The results of research related to the importance of caring are shown in the research of Reinholz *et al*., (2020) it is concluded that distance learning needs to develop an inclusive curriculum, one of which pays attention to their background, this is shown starting from their life experiences. Barry & Kanematsu (2020) as a teacher should not be too rigid, we must care about the condition of each student and continue to speak openly in providing learning support. Because some students still have difficulties in learning (Dew *et al*., 2020). Even Karakaya *et al*., (2020) distance learning even though the material standards have been set, the most important thing is to touch the nuances of the students' feelings. ask news,

Based on the opinion of experts, distance learning can be defined as a process of interaction between educators and students mediated by information technology media, this is due to the separation of space and time. Interaction during the learning process to build knowledge, meaningful learning and learning experiences. Meanwhile, the basic principles in learning which are analyzed based on expert opinion supported by empirical facts in the research are divided into 3 things, namely (1) distance learning needs to optimize motivation; (2) the use of technology in distance learning is oriented towards learning objectives and social interaction; and (3) the importance of practicing mindfulness. The three basic principles of distance learning considered in the development of learning models.

J. Characteristics of Learning Models, and Its Development

Based onFrom the results of the study, there is no specific model for developing advanced clarification critical thinking skills. In order to develop a learning model to improve the KBK-KL, it is necessary to know the concept of the learning model, and the characteristics of the model learning. The explanation in detail is as follows.

1. Learning Model Concept

The learning model is one way for educators to achieve certain learning goals (Arend, 2008:178). Likewise, Aunurahman (2009: 140) the learning model aims to create learning conditions that make students active and fun in order 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 a mature and structured plan (Joyce *et al*., 2009).

Barzegar *et al*., (2012) proved the importance of goals in the development of learning models. Based on goal setting to increase activity, participation and interest in learning. A technology-based learning model was developed by optimizing multimedia information technology as a trigger for learning interest, while activities and participation through digital communication. Researched a number of 234 high school students who are already accustomed to using technology. The results showed that the learning model designed with multimedia and digital communication systems was able to increase student interest in learning activities and participation.

In order to achieve the expected goals, the preparation of learning models needs to pay attention to diversity in the classroom, such as cognitive development, intelligence and learning styles (Arend, 2008). In a psychological study of the effectiveness of learning models, the development of learning models needs to pay attention to differences in levels of academic ability (Slavin, 2011). This opinion is reinforced by Aunurahman (2009), the development of the model needs to pay attention to differences in personality characteristics, habits, student learning modalities, facility factors such as classroom conditions, material characteristics and learning environment. Based on this opinion, there are two keywords that need to be considered in the development of the model, namely the internal factors of students which include intelligence, learning styles, abilities. academic. The two external factors are characteristics, material and environment.

There is research evidence of internal factors influencing learning outcomes. Farah & Ayoubi, (2020) examined the effect of the multiple pembelajaran learning model representation on critical thinking skills. The results of this study can be concluded that the ability to think critically is further clarified fastest the gap in results between students who have low academics and students who have high academics. Evidence of the influence of external factors as research by Khan (2018) regarding the importance of material characteristics in designing learning models. In order for abstract material to be optimal, a learning model was developed through analogy. Through the experimental method, the research results showed that the analogy method had an effect on learning outcomes on abstract material. Differences in classroom conditions and learning environment as shown by research (Ilmawati & Suherman, 2016).

Based on the opinions of experts and reinforced by research results, it can be concluded that the learning model is the achievement of learning objectives through a careful and structured plan to help students master information, generate ideas, have skills, build ways of thinking and the meaning of learning. Things that need to be considered in developing the model need to pay attention to the internal factors of students which include intelligence, learning styles, ability, academic and external factors, namely characteristics, material and environment.

2. Basic Learning Model Development

There are several opinions regarding the basis for developing learning models. First, Duke (1990) argues that to develop a learning model it is necessary to pay attention to nine elements, including: (1) providing anticipatory devices for learners, (2) clarity of material in learning, (3) clarity of objectives, (4) input for students, (5) there is a role model for students when learning, (6) there is a process of checking student understanding, (7) there is a guide in practice, 8 closures at the end of the lesson and (9) independent practice. These nine elements are ideal learning principles to help students' abilities. Each educator or model designer can analyze and select elements that are in accordance with the expected goals.

Second, Arend (2008) argues that there are at least four special characteristics of the learning model that can be used to achieve learning objectives, namely: (1) rational theoretical logical ofthe planning, (2) the learning objectives of the developed model, (3) the teaching behavior needed for learning to take place, and (4) the learning environment needed to achieve the learning objectives. The four special characteristics need to be analyzed so that the developed model has a strong foundation before being tested.

Third, the opinion of Joyce *et al*. (2009) there are five main components in the development of the model, namely 1) the syntax contains the phases of each learning activity that needs to be carried out in sequence, 2) the social system, namely the freedom of each individual to express opinions, 3) the principle of reaction, namely learning allows feedback by educators , 4) a support system, which is a device so that learning can run optimally, and 5) the impact of instructional and accompaniment impacts is the achievement of goals after the learning process. The five components need to be explained in detail by researchers to make it easier for others to implement the developed model. Another benefit is to make it easier for others to provide measurements of the developed model

Fourth, in the opinion of Marrison *et al*. (2013) there are four bases in the development of mutually exclusive models that complement each other in the development of the model. The four components are 1) for whom the learning program is developed, this is a study of the characteristics of students, 2) what is desired after students learn, this model must be able to set learning objectives, 3) how certain material subjects or skills will be taught with At best, this relates to the application of good strategies, and 4) how to determine the steps so that students achieve the goals of knowledge.

Fifth, the requirements for the learning model must meet valid, practical and effective elements (Plomp& Nieveen, 2013). The first is valid, the model can be tested by conducting content validity tests by experts that reflect theoretical rationale. In addition, it must also meet the validity of the construction, namely whether all the components in the model are consistently interrelated. Second, the practicality of the model, the learning model developed, is said to be practical if the experts and practitioners state thattheoreticalThe model can be applied in the field. The third is effective, the learning model is closely related to the achievement of learning objectives. Effectiveness is known through test results and student responses to the learning model.

Based on the opinion of experts, the development of learning models to improve students' KBK-KL in physics courses with the characteristics of (1) rational theoretical logic of the design. (2) learning objectives of the developed model, (3) learning management, and (4) learning environment needed to achieve learning objectives (Arend 2008:7). The components of the model developed will fulfill several principles (1) syntax, (2) social system, (3) reaction principle, (4) support system, and 5) instructional impact and accompaniment impact (Joyce *et al*., 2009).

K. Learning Model developed to improve KBK-KL

Based on research studies on KBK-KL, inquiry learning, learning theory, student characteristics, distance learning, the Clarity Learning Model (CLM) was developed as a hypothetical model to improve KBK-KL as shown in Figure 2.2.

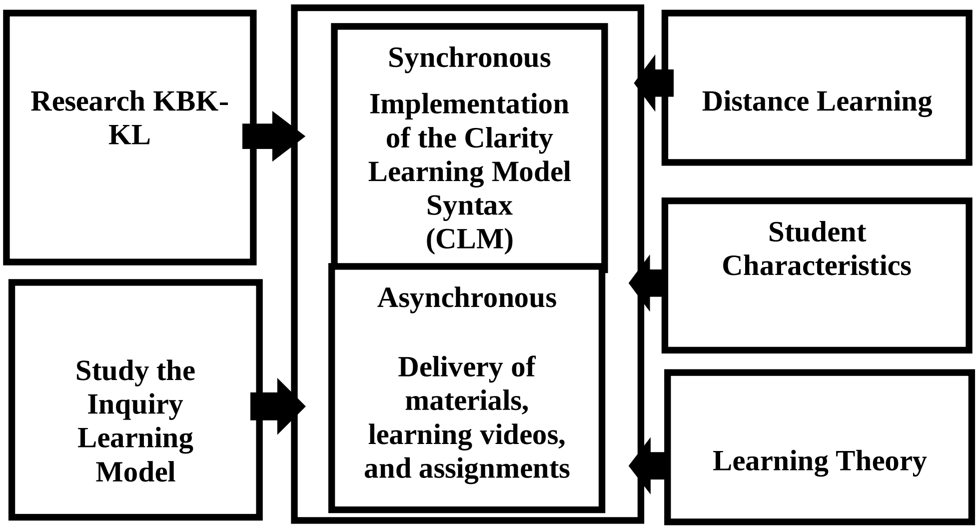


Figure 2.2 CLM Hypothetical Model Drawing forincreaseKBK-KL

This CLM innovation is expected to be an alternative solution to improve KBK-KL in basic physics courses. The specifications of the learning model developed must meet three aspects, namely 1) valid, 2) practical, and 3) effective (Plomp & Nieveen, 2013). As the learning model needs to meet the characteristics of the learning model, and the components of the model, CLM will be studied based on these rules.

1. Characteristics CLM

Arend (2008) divides the characteristics of the learning model including (1) rational theoretical logic of the design. (2) learning objectives of the developed model, (3) learning management, and (4) learning environment needed to achieve learning objectives. Following are the characteristics of CLM.

a. Syntax Design Rationality

Everyphase In the Clarity Learning Model syntax will be studied based on theoretical studies and empirical facts as the basis for logical design in model development. The development of the Clarity Learning Model applies the principles (learner-centered psychological principles) that describe students as people who are actively seeking knowledge (Slavin, 2011). The rationale for the formation of the CLM syntax which consists of five learning phases is shown in Figure 2.3

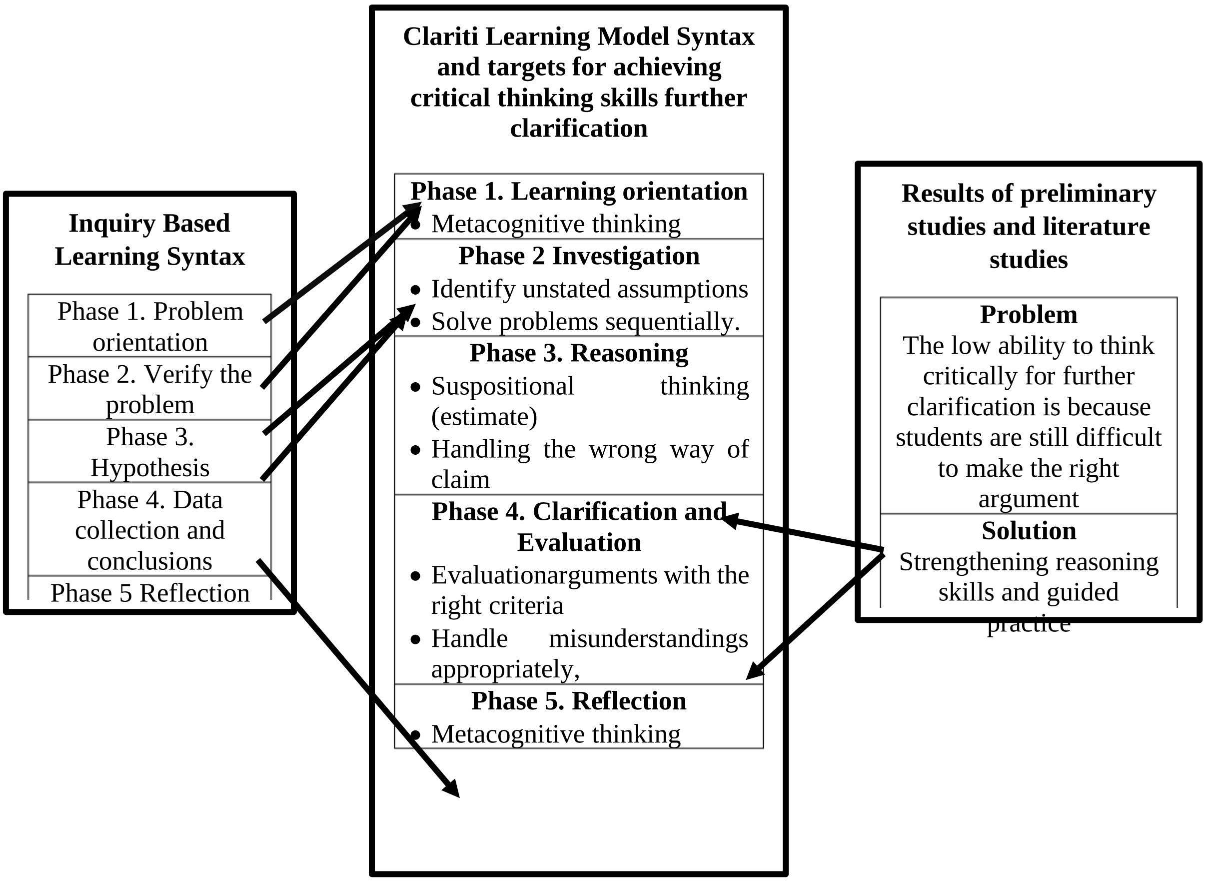


Figure 2.3 The Origins of the Stages of the CLM Model

Based on Figure 2.3 shows that Phase 1. Learning orientation is adapted from the problem orientation and problem verification phase in IBL. This phase aims to develop KBK-KL on indicators of metacognitive thinking. Phase 2. The investigation is adapted from the hypothesis phase, data collection, and making conclusions that exist in the IBL phase. This phase aims to develop KBK-KL indicators, identify unstated assumptions and solve problems in order.

Phase 3. Reasoning, is a solution to the problems faced by students in making arguments. This phase aims to develop KBK-KL in predictive thinking indicators and handling error labels. Phase 4. Clarification and evaluation are solutions to problems faced by students in making arguments. This phase aims to develop KBK-KL indicators, assess phenomena based on appropriate concepts and evaluate a person's line of thought. Phase 5. This phase was adapted from the evaluation phase of the investigation in IBL. This phase aims to develop KBK-KL on indicators of metacognitive thinking. While each phase of the CLM syntax has theoretical and empirical support, it is shown in Table 2.7

Table 2.7 Theoretical and Empirical Support for CLM Design

CLM Syntax	Theoretical Support	Empirical Support
Learning Orientation Phase Train KBK-KL on indicators of metacognitive thinking.		
Appreciation, and Motivation	1. Although the direct face-to-face technology is favored by Generation Z students (Seemiller & Grace, 2016:59). 2. Interactions related to personality values and feelings of pleasure can	1. He naturally likes to be cared for by others which is shown through communication (Yu, 2016; Miller, 2019). 2. The paradigm of facilitating learning to students needs to be put forward in distance learning (Danjou, 2020).

CLM Syntax	Theoretical Support	Empirical Support
	increase learning motivation (Anjana, 2018:16) 3. Providing services to students in distance learning is a very important factor because they often have obstacles or problems (Anjana, 2018:98; Bork & Gunnarsdottir, 2001:92) 4. Social and contextual factors influence motivation in online learning environments (Hartnett, 2016:2)	3. Distance learning needs to develop an inclusive curriculum, one of which takes into account their background (Reinholz *et al*., 2020). 4. as a teacher, don't be too rigid, we must care about the condition of each student (Barry & Kanematsu, 2020; Dew *et al*., 2020; Karakaya *et al*., 2020) 5. Hidayat & Wibawa's research, (2020) suggests that distance learning applying communication patterns built in the classroom needs to foster student motivation and interest in learning. 6. The results of the research by Pratama *et al*., (2020) concluded that the existence of learning facilities both face-to-face and online was able to facilitate communication interactions and was effective towards learning objectives. 7. The results of Purcell & Purcell's research, (2019) they want to apply the theory they already have to solve problems in the world of work.
Authentic Troubleshooting	1. The right step for students to construct knowledge is through an event (Ray, 2002; Chang, 2005). 2. According to Piaget, the process of assimilation and accommodation is motivated by the need to find equilibrium, usually a phenomenon that affects	1. The results of Prayogi & Verawati's research, (2020) that the provision of cognitive conflict in inquiry learning has a significant effect on the critical thinking skills of prospective physics teachers 2. Authentic problems contain puzzles and activities Hypothetical and experimental

CLM Syntax	Theoretical Support	Empirical Support
	conflict, cognitive or curious events (Moreno, 2010:79). 3. Giving problems is able to arouse curiosity and motivation to learn (Slavin, 2011: 8; Arend, 2008: 47) 4. Every given phenomenon will be responded to through organizing the knowledge that has been possessed (schemata) which is called assimilation (Arend, 2008:34). 5. Through questions, they will be responded back by making efforts to find answers to match what they have found with their predictions, comparing their findings with the findings of other friends (Arend, 2008:105). 6. Giving difficult topics and mind-blowing questions makes critical thinking skills stronger (Peter Facione, 2016:9).	activities can improve critical thinking skills of advanced clarification components (Mundilarto & Ismoyo, 2017; Kadarwati 2020; Rahmi *et al*., 2019; and Diani *et al*., 2020). 3. Problems have an impact on students' curiosity and this is what will lead them to carry out investigations to find results that are as accurate as possible (Facione, 1990).
Learning objectives	1. Metacognition is the activity of monitoring and regulating their own learning (Arend, (2008:30). 2. Monitoring can be in the form of understanding, the time needed to learn, effective strategies for learning and or working	1. Learning will be maximized if educators provide space for students to solve problems together (Higgins, 2014) 2. Knowledge can be increased due to a joint problem-solving process (Burn., 2014) 3. The results of the research by Samsudin & Hardini (2019)

CLM Syntax	Theoretical Support	Empirical Support
	on questions (Slavin, 2011:253)	stated that metacognition had a significant effect on critical thinking. 4. Educational level affects students' metacognitive abilities. Higher levels of education have better metacognitive abilities than those below
Assignment Agreement, and learning activities	1. Adults prefer to socialize and cooperate with certain characters in a group (Garry *et al*., 2013: 58). 2. Adults like to discuss and are willing to receive knowledge based on reasons and evidence (Upton & Trapp, 2010:68; Slavin, 2011:54). 3. Interactionrelated to personality values and feelings of pleasure can increase learning motivation (Anjana, 2018:16)	3. Student involvement in determining online learning activities is a determinant of success in learning (Baber, 2020; Wong *et al*., 2019). 4. Learning planning arrangements that involve students have an impact on increasing self-regulation learning (Xu & Ko, 2019)
Investigation Phase Train KBK-KL on indicators of metacognitive thinking identify unstated assumptions and solve problems in order		
Group work starting from hypotheses, data collection and investigation reports	1. Modules or guides in distance learning can reduce confusion. 2. Thinkercritical has characteristics diligent in seeking relevant information, reasonable in the selection of criteria, focused on investigation and persistent in seeking results that are as accurate	1. Aljanazrah, (2020) so that independent learning requires very clear and detailed materials, one of which is providing video content for the experimental learning process in a simulation. 2. generationZ places technology as an inseparable part of their lives to solve the problems they face (Wood, 2013; Geck, 2006).

CLM Syntax	Theoretical Support	Empirical Support
	as possible (Facione, 1990) 3. Skepticism reflective thinking will be able to optimize critical thinking skills (McPeck, 1981:3). 4. Thinkingcritical thinking can be done through the act of observation, categorization and assessment (Stephen Johnson; Harvey Siegel, 2010:40) 5. So, the learning process needs to pay attention to learning activities to test theories and clarify concepts learned through learning activities (Moore, 2010:3-4). 6. With The existence of social interaction will spur the development of new ideas and enhance intellectual development or Zone of Proximal Development (ZPD)(Arend, 2008:105; Slavin, 2011:4) 7. Studentincluded in the formal operational category so that they are able to be involved in solving abstract problems (Slavin, 2011:45; Arend, 2008:35). 8. One's cognitive participation such as analysis, interpretation, inference and sharing activities number	3. Hypothesis and experimental activities can improve critical thinking skills of advanced clarification components Mundilarto & Ismoyo, (2017) Kadarwati 2020; Rahmi *et al*., 2019; Diani *et al*., 2020) 4. GenerationZ has an open attitude to anyone, and wants interaction in an interactive communication pattern or not one communication (Seemiller & Grace, 2016: 26-27; Fernández & Fernández, 2016). 5. Involvement Students in activities learning online success determinant instudy (Baber, 2020)

CLM Syntax	Theoretical Support	Empirical Support
	construct knowledge (Chang, 2005).	
	Reasoning Phase Train KBK-KL on predictive thinking indicators and handle label errors	
Task Evaluation and discussion	1. Associating new information with information from others who saved a long memory will lead to meaningful learning (Moreno, 2010:203; Tomei, 2010:27; Slavin, 2011:250). 2. Metacognition is the activity of monitoring and regulating their own learning (Arend, (2008:30). 3. Formationnew schemata through asking questions, and making efforts to find answers matching what they have found with their predictions, comparing their findings with the findings of other friends (Arend, 2008:105). 4. Critical thinking is based on the ability to think rationally with appropriate explanations based on evidence (Ennis, 1985a; Halpern, 1999:72-73; McPeck, 1981:3 and Siegel, 1991:23).	1. Giving materials and assignments is liked by students because they can learn and do assignments at various speeds Ab & Algeria, (2020) 2. Students' difficulties in completing critical thinking skills in the clarification component advanced to connect the theory that has been studied with the problem at hand (Sumarni & Kadarwati, 2020). 3. Reasoning tasks can improve students' critical thinking skills (Saputro, Arifin, *et al*., 2020; Roberson & Franchini, 2014; and Wang *et al*., 2019). 4. Optimizing practice and guidance in working on critical thinking tests (Diani *et al*., 2020; Herunata *et al*., 2020)
	Clarification and Evaluation Phase Train KBK-KL on indicators of assessing phenomena based on appropriate concepts and evaluating one's line of thought.	

CLM Syntax	Theoretical Support	Empirical Support
Giving Quiz and discussion	1. Knowledge is not static and will continue to grow and change because students experience new experiences and force them to modify knowledge independently (Arend, 2008: 34). 2. With social interaction, it will spur the development of new ideas and increase intellectual development or the Zone of Proximal Development (ZPD) (Arend, 2008:105; Slavin, 2011:4). 3. The Zingin generation has interactions in communication patterns or not one-way communication, which is ready to accept all ideas and want to be heard every time (Seemiller & Grace, 2016:26-27). 4. Students can ask questions, and make efforts to find answers to match what they have found with their predictions, compare their findings with other findings (Arend, 2008: 105) 5. Associating new information with information from others who have saved memory for a long time will lead to meaningful learning (Moreno, 2010:203;	1. Generation Z has an open attitude to anyone, and wants interaction in an interactive communication pattern or not one-way communication (Fernández & Fernández, 2016). 2. Multiple representations help improve critical thinking skills in the advanced clarification component (Herawati *et al*., 2020) 3. He naturally likes to be cared for by others which is shown through communication (Yu, 2016; Miller, 2019). 4. The provision of training and guidance is needed to practice critical thinking skills (Diani *et al*., 2020; and Herunata *et al*., 2020). 5. Differences in the initial abilities possessed by learners (Herunata *et al*., 2020). 6. The difficulty of learners in connecting between the theory that has been studied with the problem at hand (Sumarni & Kadarwati, 2020) 7. Exerciseguided can improve critical thinking skills. Giving difficult topics and mind-blowing questions makes critical thinking skills stronger (Facione, 2016)

CLM Syntax	Theoretical Support	Empirical Support
	Tomei, 2010:27; Slavin, 2011:250). 6. The formation of new schemata through asking questions, and making efforts to find answers matching what they have found with their predictions, comparing their findings with the findings of other friends (Arend, 2008:105). 7. Critical thinking skills are based on the ability to think rationally with appropriate explanations based on evidence (Ennis, 1985a; Halpern, 1999:72-73; McPeck, 1981:3; Siegel, 1991:23).	
	Reflection Train KBK-KL on indicators of metacognitive thinking	
Reflection and reinforcement of the material	1. Metacognition Is to monitor and regulate their own learning (Arend, (2008:30). 2. Monitoring can be in the form of understanding, the time needed to learn, effective strategies for learning and or working on questions (Slavin, 2011:253)	1. Research resultSamsudin & Hardini, (2019) stated that metacognition has a significant effect on critical thinking. 2. Higher education levels have better metacognitive abilities than those below (Fauzi & Sa'diyah, 2019)
The task of summarizing the material in the form of a mind map chart	meaningfulness learning can be done through connecting new information with previous knowledge that exists in themselves (Moreno, 2010:203; Tomei, 2010:27)	1. improve critical thinking skills (Prayogi & Verawati, 2020). 2. Making certain products in learning can improve learning outcomes (Saputro *et al*., 2014)

Based on Table 2.7 can be described rationally CLM design. Phase-1: Learning orientation. PhaseIn this, students will be presented with authentic problems, delivery of goals, mutual agreement. This activity strengthens the problem presentation phase in the inquiry model (Arend, 2008). This phase was chosen based on previous research suggestions which stated that through presenting authentic problems it could provide a stimulus for critical thinking skills (Mundilarto & Ismoyo, 2017; Kadarwati 2020; Rahmi *et al*., 2019; Diani *et al*., 2020). The right step for students to construct knowledge is through an event (Ray, 2002; Chang, 2005). In cognitive theory, each given phenomenon will be responded to through organizing the knowledge that has been possessed (schemata) which is called assimilation (Arend, 2008:34; Moreno, 2010). Providing information on the purpose of problem solving to achieve certain learning objectives, so that in order to be maximal in achieving student goals, students make lesson plans implementing metacognitive theory (Moreno, 2010).

Activity Learning is carried out face-to-face synchronously, facilitated by technology using a video conference learning platform, which is the main characteristic of distance learning (Jung & Richter, 2019:1; Sewart, 2014). The purpose of this technology is to facilitate students to interact directly (Seemiller & Grace, 2016). Interaction will strengthen an important factor in distance learning, namely learning motivation (Anjana, 2018), and facilitating social factors that are owned by every human individual (Hartnett, 2016). Another technology used is the Learning Management System (LMS) as a medium for sending learning resources such as textbooks, Phet Simulation programs, sending action plan sheets, this will streamline the learning process and objectives (Pratama *et al*., 2020).

The learning objectives are related to the benefits that will be obtained for the field of informatics, this is because generation Z students are very realistic in thinking (Seemiller & Grace, 2016:123-124). Students want to apply the theory they already have to solve problems in the world of work (Purcell & Purcell, 2019). So that it will foster motivation and interest in learning for each student (Hidayat & Wibawa, 2020).

DesignPhase 1 learning begins with questions, delivery of clear learning objectives, taking into account student characteristics, and distance learning success factors, notification of learning objectivesactivityThis was the purpose of trainingKBK-KL on metacognitive thinking indicators.

Phase-2: Investigation. ActivityThe investigation includes determining hypotheses, collecting data through experiments, concluding that they are carried out in groups. This activity combines the phases of data verification, hypothesis, data collection and explanation of the inquiry model (Arend, 2008). This phase is the implementation of the essence of critical thinking skills: process thinking rationally with appropriate explanations based on evidence (Ennis, 1985a; Halpern, 1999; McPeck, 1981; Siegel, 1991). This activity is also based on research suggestions which contain that it is necessary to hypothesize and prove hypotheses to build one's critical thinking skills (Mundilarto & Ismoyo, 2017; Kadarwati 2020; Rahmi *et al*., 2019; Diani *et al*., 2020).

In theory of learning, the process of inquiry can optimize one's cognitive participation such as analysis, interpretation, inference and sharing activities number construct knowledge (Chang, 2005). Investigation is a cognitive process that builds knowledge through matching new data or situations to existing schemata to develop new concepts or schemata called accommodation (Arend, 2008; Moreno, 2010). It is the basis of discovery learning theory, namely the concept is not the result of giving but needs to be discovered by students (Moreno, 2010). The emphasis on learning needs to emphasize inductive reasoning and the process of inquiry (Arend, 2008; Slavin, 2011). Activities that involve the five senses, thinking and actively conducting experiments will be able to form students' knowledge independently (Arend, 2012). Group activities are the application of social constructivist theory of scaffolding in learning (Moreno, 2010.

Practical activities in groups facilitate generation Z in being an open person through interactions in interactive communication patterns (Seemiller & Grace, 2016; Fernández & Fernández, 2016). Besides that group activities will optimize the involvement of students in activities learning so that the learning objectives can be effective (Barber, 2020). Discussion activities are the character of adult learners because knowledge is acceptable based on reasons and evidence (Upton & Trapp, 2010; Slavin, 2011).

Technology Distance learning using a video conference learning platform as a discussion medium (Jung & Richter, 2019; Sewart, 2014). The purpose of this technology is to facilitate students to interact directly (Seemiller & Grace, 2016). Another technology used is the Learning Management System (LMS) as a medium for sending assignments in the form of practicum reports and posters that will streamline learning objectives (Pratama *et al*., (2020). The assignment of advanced organizers can improve critical thinking skills (Prayogi & Verawati, 2020) and learning outcomes (Saputro *et al*., 2014).

The learning design in the investigation phase which contains hypothetical activities aims to train critical thinking ability on advanced clarification in the form of indicators for identifying assumptions that are not stated, predictive thinking. Practical activities to make conclusions, and discuss the results of the investigation aimed at training KBK-KL on indicators of metacognitive thinking identify unstated assumptions and solve problems in order.

Phase-3: Reasoning.Activities In the form of working on independent tasks containing elaboration and practice questions, this is the implementation of research suggestions that contain the need for guided exercises (Diani *et al*., 2020; Herunata *et al*., 2020). Guidance in this phase is in the form of a textbook guide that is structured with a certain structure to clarify the study material (Bork & Gunnarsdottir, 2001:165; Aljanazrah, 2020). This activity is expected to be able to minimize the non-optimal critical thinking ability on advanced clarification caused by the low reasoning abilities of learners (Pradana & Parno, 2017; Sumarni & Kadarwati, 2020; Herunata *et al*., 2020; and Herawati *et al*., 2020). Low initial ability as the basis of reasoning (Herunata *et al*., 2020), will be minimized through elaboration of tasks that are guided in student textbooks aimed at strengthening the knowledge that has been obtained (Moreno, 2010; Slavin, 2011).

Next Weak Linking the problems encountered with the use of appropriate concepts (Sumarni & Kadarwati, 2020), will be minimized through textbook instructions to find the right concept in solving problems (Saputro, Arifin, *et al*., 2020; Roberson & Franchini, 2014; and Wang *et al*., 2019). The low ability to describe concepts (Pradana & Parno, 2017; Sumarni & Kadarwati, 2020; Herunata *et al*., 2020; and Herawati *et al*., 2020) will be facilitated in textbooks through written language representation activities (Herawati *et al*., 2020).

Learning theory foundation meaningful learning that is associating new information with information of others who have saved memory for a long time (Moreno, 2010; Tomei, 2010; Slavin, 2011). Reinforced by cognitive theory that contains the formation of new schemata through asking questions, and making efforts to find answers matching what they have found with their predictions, comparing their findings with the findings of other friends (Arend, 2008). When completing tasks independently, students actively carry out the reasoning process to re-conceptualize the knowledge gained through experimentation, which is the application of cognitive constructivist theory (Aunurahman, 2009).

The technology used is the Learning Management System (LMS) as a medium for sending independent assignments to streamline learning objectives (Pratama *et al*., (2020). In addition, it is a tool for detecting abilities and measuring abilities possessed by students.so that it can be used for determining learning policies (Hoq, 2020). Also pay attention to the habits of Generation Z who are accustomed to solving problems using technology through the opportunity to find other sources of information to solve problems (Wood, 2013; Geck, 2006). The learning design in the reasoning phase aims to train KBK-KL on indicators of predictive thinking and dealing with label errors

Phase 4. Clarification and Evaluation. This phase strengthens the explanation phase contained in the inquiry model. In addition to the explanation in the form of presentation of the results of the practicum, there are additional activities in the form of discussion of independent assignments and confirmation of knowledge through evaluation. This activity is carried out in order to clarify students' critical thinking skills through guided activities (Diani *et al*., 2020; Herunata *et al*., 2020). Guidance in this phase is guided directly by the lecturer, this will streamline the learning process and objectives (Pratama *et al*., (2020). The activity of delivering arguments and additional critical thinking skills training through questions are expected that students have two experiences in working on questions related to critical thinking skills. So that the number of practice questions students will be more skilled in solving problems related to critical thinking skills (Halpern, 2014: 37; Ennis, 2016).

Learning theory foundation meaningful learning that is associating new information with information of others who have saved memory for a long time (Moreno, 2010; Tomei, 2010; Slavin, 2011). Reinforced by cognitive theory that contains the formation of schemata is carried out through activities discuss together (Arend, 2008). With social interaction, it will spur the development of new ideas and increase intellectual development or the Zone of Proximal Development (ZPD) (Arend, 2008; Slavin, 2011).

Learning activities are carried out face-to-face synchronously using a video conference learning platform (Jung & Richter, 2019; Sewart, 2014). The purpose of this technology is to facilitate students to interact directly (Seemiller & Grace, 2016). Interaction will strengthen learning motivation (Anjana, 2018), and facilitate social factors that are owned by every human individual (Hartnett, 2016). Another technology used is the Learning Management System (LMS) as a medium for sending quiz results, this will streamline the learning process and objectives (Pratama *et al*., (2020). The learning design in the clarification and evaluation phase aims to train KBK-KL on indicators of assessing phenomena based on appropriate concepts and evaluating one's line of thought.

Phase 5. Reflection. This phase is individual in that each student makes a reflection on an action plan, and makes a mind map chart. This phase is supported by the theory of meaningful learning through information organization, namely giving an orderly structure to pieces of information to create visuals of all concepts, for example by making concept maps (Moreno, 2010; Slavin, 2011). It is also supported by metacognition theory which contains strategies for assessing their own understanding by finding out how much time they need to learn something and choosing an effective strategy for learning and or working on problems (Slavin, 2011).

Another technology used is the Learning Management System (LMS) as a medium for sending the results of reflection work on action plans and mind mapping charts, this will streamline the learning process and objectives (Pratama *et* *al*., (2020). Phase reflection aims to train KBK-KL on indicators of metacognitive thinking.

b. Learning objectives.

CLM is designed with the main objective to improve students' KBK-KL in basic physics courses by strengthening concepts through investigative activities which are the core of inquiry learning and strengthening reasoning and optimizing guided exercises.

c. Learning management.

Management learning in the Clarity Learning Model, in the investigation phase, students in groups in solving assignments will have an impact on increasing a culture of mutual respect, friendly communication and good cooperation to achieve common goals. The reasoning phase has an impact on the development of critical thinking skills, problem solving skills, multiple representation and metacognition.

d. Learning Environment

Environment learning in Clarity Learning Model integrate domain affective, cognitive and psychomotor are expected to achieve critical thinking skills in the advanced clarification component. The details are described in Table 2.8.

Table 2.8 CLM Learning Environment

Learning Environment
Phase 1: Learning orientation 1. Lecturers give a sense of care by greeting and asking about conditions as an effort to maintain learning motivation 2. Lecturers’ open questions and answers showing an open sense of everything in order to foster comfort in learning 3. Lecturers provide phenomena and questions to grow the cognitive domain of students' critical thinking 4. Students formgroup independently consisting of 4-5 students’ group to foster mutual respect and good cooperation 5. Students make plans for completing assignments that will have an impact on students' metacognitive abilities.
Phase 2 investigation 1. Students discuss in groups to foster a culture of critical thinking and mutual respect. 2. Students conduct investigations to build a critical culture, and are skilled in using equipment certain 3. Students analyze results the findings to optimize representation capabilities and optimize culture critical thinking
3rd phase of reasoning 1. Students are used to predicting based on science to improve critical thinking skills 2. Students elaborate to strengthen knowledge 3. Students work on independent reasoning tasks to optimize
Phase 4 Clarification and evaluation 1. Lecturers give greetings to improve a caring culture and maintain the spirit of learning 2. Students listen to the summary of the evaluation results whole to increase mutual respect

3. Lecturers involve students in the problem-solving process, which will foster confidence in their abilities. 4. Students ask if anyone is still confused to foster a critical attitude and a sense of openness in learning 5. Students take quizzes to improve critical thinking skills 6. Lecturers evaluate each quiz; it will foster a positive academic culture.
Phase 5 Reflection 1. Studentindependently evaluate the target plan and make recommendations for improvement, this will foster a critical attitude 2. Students making summaries will foster an academic culture 3. Students submitting their summary results in LMS can practice digital literacy skills

2. CLM Model Components

The components of the developed CLM model are contained in a phase or syntax. According to Joyce *et al*., (2009:7-30) there are five components mainin the development of the model, namely 1) syntax, 2) social system, 3) reaction principle, 4) support system, 5) instructional impact and accompaniment impact.

a. Syntax

CLM has a syntax consisting of 5 phasesnamely 1) learning orientation 2) investigation 3) reasoning 4) clarification and evaluation 5) reflection, allactivity learning detailed in Table 2.9.

Table 2.9 Learning Activities in CLM Syntax

CLM Syntax	Lecturer Activities	Student activities
Learning Orientation Phase	The lecturer gives an authentic phenomenon, then asks students to comment on the phenomenon.	Students respond to authentic phenomena given by the lecturer.

CLM Syntax	Lecturer Activities	Student activities
	Lecturers convey the relationship of authentic phenomena with learning objectives.	Students listen to the relationship between phenomena and learning objectives.
Investigation Phase	The lecturer accompanies a series of investigations ranging from problem formulation, hypotheses, data collection, and conclusions to students and asks students to report the results of their investigations.	Students carry out investigations starting from filling in problem formulations, hypotheses, collecting data and making conclusions. Student representatives present the results of the investigation.
Reasoning Phase	Lecturers appoint student representatives to deliver reasoning exercises, discussions, and discussions. Then give students the opportunity to ask questions if there is something they don't understand.	Students deliver exercises about reasoning and discussion. If students have not been able to master the concept, then students can ask the lecturer directly.
Clarification and Evaluation Phase	Lecturers give quizzes containing exercises on critical thinking skills for further explanation. Lecturers discuss the results of practice questions and provide opportunities for students to ask questions if something is not understood	Students do the exercises that have been given by the lecturer. If students have not been able to master the concept, then students can ask the lecturer directly.
Reflection Phase	Lecturers reflect through summaries made of questions such as what is an example of a job? The lecturer asks students to summarize the material in the form of a mind map diagram.	Students together answer a brief summary of the material questions. Students collect mind map charts in LMS.

b. Social System

Systemsocial explain the role and relationship of lecturers with students, and peer relations during the learning process (Joyce *et al.*, 2009). The Clarity

Learning Model puts forward respect for lecturers towards students as shown in phase-1 of learning orientation, and phase-4 of clarification and evaluation. This is indicated by mentioning names, and thanking students for their presence. This is based on the results of research which states that Generation Z respects people who know themselves (Yu, 2016; Miller, 2019). Likewise, the curriculum that needs to be considered for distance learning is inclusive, one of which pays attention to their background (Reinholz *et al*., 2020).

Form Respecting students and lecturers through discussions, student involvement in determining learning bills, group formation discussions in phase 1 of learning orientation and question and answer discussion in phase 4 of clarification and evaluation. This is because every decision concerning adolescent children requires an involvement process or a joint discussion (Garry *et al*., 2013; Slavin, 2011; Tomei, 2010). The impact of student involvement in determining online learning activities is a determinant of success in learning (Baber, 2020; Wong *et al*., 2019), and increasing self-regulation learning abilities (Xu & Ko, 2019).

The pattern of communication during discussions between lecturers and students in phase 4 of clarification and evaluation, and discussions during phase 2 with fellow students emphasizes open intellectuality. This is due as adult learners accept knowledge of reason and evidence (Upton & Trapp, 2010:68; Slavin, 2011:54). As the main characteristic in critical thinking skills, acceptance of an idea is not based on age level but based on rationality based on evidence(Ennis, 1985a; Halpern, 1999; McPeck, 1981; Siegel, 1991).

Patterncommunicationlecturers and students prioritize caring. namely in phase 1 of orientation and phase -4 of clarification and evaluation, the lecturer asks all students whether what has been conveyed has been understood or not. So the role of the lecturer is as a guide, moderator, facilitator, evaluator and creates a comfortable atmosphere when learning takes place. There are many obstacles experienced by students during distance learning, so as a teacher it is necessary to show an open attitude to students to provide learning services (Anjana, 2018; Bork & Gunnarsdottir, 2001). The paradigm of facilitating learning to students needs to be prioritized in distance learning (Danjou, 2020).

c. Reaction Principle

The principle of this reaction is related to how to respond to questions, answer responses. Like the social system in CLM, namely respect, caring and open intellectuals. So the consequence that must be done as an educator is to always respond to every question and the results of the performance that has been done by students. Phase-1 learning orientation, the lecturer will ask understanding level questions and answer each question to gain clarity. As a teacher, don't be too rigid, we must care about the condition of each student (Barry & Kanematsu, 2020; Dew *et al*., 2020; Karakaya *et al*., 2020). Lecturers give polls to students to obtain data on difficulties faced by students when doing independent assignments. The data from the poll was followed up by emphasizing material that was still included in the difficult category by students.

Phase-4 clarification and evaluation contains an activity to evaluate group work reports and independent assignments. Lecturers will give appreciation to students who have worked hard while completing the learning bill which is delivered directly via video conference. In addition, the lecturer will also provide confirmation for concepts that are still considered difficult by students. So that students have the same perception, the lecturer gives students the opportunity to ask questions if there is ambiguity in the delivery of the lecturer. With social interaction, it will spur the development of new ideas and increase intellectual development or Zone of Proximal Development (ZPD) (Arend, 2008; Slavin, 2011.The paradigm of facilitating learning to students needs to be prioritized in distance learning (Danjou, 2020).

Paid Phase-5 students collect action plan reflection sheets and mind map charts will be responded back by the lecturers through the delivery of information via social media whatsapp. Through the principle of reaction in CLM will strengthen the achievement of learning objectives, namely the ability to think critically for advanced clarification.

d. Support System

The support system is all the means, materials or tools to implement CLM. Before the learning process, the main components of CLM need to be preparedcoversRPS, SAP, student textbooks, KBK-KL tests, learning constraint sheets, and student response questionnaires are available. In the application of CLM, an online learning platform is needed, such as zoom meetings for video conferences, LMS as a learning resource can be filled with CLM learning tools, Phet Interactive Simulations software, video tutorials and so on. Other supporting materials such as laptops, electricity network, and smooth internet network. The availability of examples of completion of further clarifying critical thinking ability test items in Textbooks can provide inspiration for students in doing reasoning tasks in phase-and quizzes in phase-4. The role of lecturers who have a paradigm of ready to serve will support the success of learning with CLM.

e. Instructional Impact and Accompaniment.

Wrong Learning model reference is said to be effective, if the implementation is able to produce and achieve what is the main goal as the impact of instruction in learning. Through learning activities that optimize the investigation process, guided reasoning exercises twice and discussions and evaluations of each student's performance results are expected to be able to improve critical thinking ability on advanced clarification.

Impact Accompaniment Is another learning result created from the learning process experienced during the CLM learning process, namely:

1. Through the LMS learning media platform, learning independence will be formed.
2. **Phase-1: learning orientation there** is an assignment to make an action plan and phase-5 reflection on the action plan, this will train metacognition skills.
3. **Phase-2: investigation with** the formation of groups will develop good communication and cooperation in all situations
4. **Phase-2: investigate the** existence of a practicum report in the form of making posters, phase-4: clarification and evaluation of the presentation of results and

phase-5: reflection on making mind map charts, will train skills of multiple representation.

5. **Phase-3: reasoning it** is hoped that students will optimize every resource they have, both notebooks and the use of technology to be able to complete assignments right on target, this will develop problem solving skills.
6. **Use of multiple platforms such** as video conferencing, LMS, poster making will also train digital literacy skills.

L. Novelty

The main basis of the novelty of CLM is that it focuses on measuring advanced clarification critical thinking skills, then it is strengthened that there is no inquiry-based learning intervention to measure all indicators of advanced clarification critical thinking skills consisting of seven indicators as shown in Figure 2.2. The second novelty lies in the syntax or the learning phase, this is shown in Figure 2.3. and CL has distinctive value in communication patterns.

The first novelty of CLM focuses on improving critical thinking ability on advanced clarification. Many learning models have contributed to improving critical thinking skills. However, the critical thinking skills developed by Ennis (2016) on the advanced clarification component are not yet fully optimal. The learning models are problem-based learning or PBL (Mundilarto & Ismoyo, 2017; Awan *et al*., 2017), project-based learning models or PjbL (Sumarni & Kadarwati, 2020; and Taufiq *et al*., 2020), inquiry learning models or IBL (Irwanto *et al*., 2018; Zain & Jumadi, 2018; Herawati *et al*., 2020; Pursitasari *et al*., 2020; Prayogi &

Verawati, 2020), learning model Structuring a new Socioscientific Issues (Davut Gul & Akcay, 2020) and the FERA learning model, namely Focus, Explore, Reflect and Apply (Diani *et al*., 2020).

CLM was developed to improve critical thinking ability on advanced clarification. This is described as a learning model that will measure all indicators of critical thinking ability on advanced clarification consisting of seven indicators. The indicators of critical thinking ability for advanced clarification include defining terms, and assessing definitions based on appropriate criteria, handling misunderstandings appropriately, identifying unstated assumptions, suppositional thinking (estimations), handling wrong claims, metacognitive thinking, and solving problems sequentially.

However, based on a study of the inquiry learning model as the basis for developing CLM, data was obtained that it was only used to measure two indicators. First, define terms and assess definitions based on appropriate criteria (Irwanto *et al*., 2018; Zain & Jumadi, 2018; Rahmi *et al*., 2019; Herawati *et al*., 2020; Maknun, 2020; Pursitasari *et al*., 2020). The second indicator is identifying unstated assumptions (Irwanto *et al*., 2018; Herawati *et al*., 2020; Maknun, 2020; and Purwitasari *et al*., 2020).

The second novelty lies in the syntax or phase. Based on information from the study of the research results, the researcher determined the inquiry model developed byArend, (2008) and Joyce *et al*., (2009) as the basis for model development. Differences in syntax or learning phases are shown in Table 2.10. The CLM syntax was developed to strengthen the query syntax (Arend, 2008; Joyce *et al*., 2009), the difference between the two lies in the third and third syntax. fourth

CLM. The following comparison of inquiry learning with CLM is shown in Table 2.10.

Table 2.10 Syntax Comparison of Inquiry Learning Model with CLM

Inquiry Learning Model	**CLM models**
1. Presentation of the problem situation	1. Learning Orientation
2. Verification Problem	
3. Hypothetical	2. Investigation
4. Data collection and explanation	
	3. Reasoning
	4. Clarification and Evaluation
5. Evaluation of the investigation process	5. Reflection

Based on Table 2.10 the difference between CLM and inquiry learning lies in the third syntax, namely reasoning, this becomes a new phase based on the evaluation results that learners have difficulty connecting their knowledge with the types of questions asked.(Sumarni & Kadarwati, 2020). The concept of reasoning needs to be strengthened because critical thinking skills are good reasoning skills based on evidence (Ennis, 1985a; Halpern, 1999; McPeck, 1981; Siegel, 1991). Reasoning tasks can improve critical thinking skills (Saputro, Arifin, *et al*., 2020; Roberson & Franchini, 2014; Wang *et al*., 2019).

The second difference is in the 4th syntax, namely clarification and evaluation, this is due to the factors that cause low critical thinking skills in critical thinking skills, advanced clarification is unfamiliar with the type of questions (Pradana & Parno, 2017; Sumarni & Kadarwati, 2020; Herunata *et al*.., 2020;

Herawati *et al*., 2020). So students need additional questions to get used to solving various problems. This phase facilitates students to practice again through evaluation, this is because the lecturer wants to confirm their abilities through additional questions or tests. This activity takes place synchronously due to the need for guidance in training (Halpern, 2014: 37); Herunata *et al*., 2020).

CLMhavedistinctive value in communication patterns. The role of the lecturer in this model is necessary to emphasize on the characteristics of students as learners who are teenagers and generation Z with their peculiarities. This is shown in the first phase, namely the orientation of the activity steps to involve students in optimizing task completion, this is in accordance with the character of adolescent learners who want to be involved in decision making (Garry *et al*., 2013).

Generation Z characters are realistic in action, they will be motivated if there is a benefit to be gained(Seemiller & Grace, 2016). So that at the beginning of a face-to-face meeting, a lecturer needs to show the relationship between the material and the career world. The next thing that really stands out is putting forward concern for Gen Z students, they like to be cared for and care about other people's activities (Yu, 2016; Miller, 2019).In its implementation, a lecturer needs to say hello by name with several things that touch positive feelings, such as related to hobbies when interacting in virtual classes.

M. Conceptual Framework

The undergraduate program is oriented towards preparing students to become intellectuals and/or scientists who are cultured, able to enter and/or create jobs, and are able to develop themselves into professionals. (Ministry of Education and Culture 2012, Article 18:2). So it takes the ability that is obtained through the internalization of knowledge, attitudes, skills, competencies, through learning design (Presidential Regulation of the Republic of Indonesia number 8, 2012). The ability needed for the world of work is the ability or critical thinking skills (Peter Facione, (2016; Wallace, 2001).

Critical thinking skills are also needed in today's conditions with the characteristics of volatility, uncertainty, complexity, and ambiguity or often referred to as VUCA (Raghuram Patruni & Kosuri, 2017). The role of critical thinking skills in the VUCA era is to provide an assessment of facts or information processed by a robotic system as the basis for improving the results of the work done (Guo & Cheng, 2019). The results of other studies show that critical thinking skills are useful for solving problems in various situations, even new situations that have never happened before (Raghuram Patruni & Kosuri, 2017; Poernomo, 2020). Another benefit is as a basis for precise and accurate decision making (Amelia *et al*., 2019).

Before training critical thinking skills through the learning process, it is necessary to first define the concept of thinking based on higher education achievement targets. Critical thinking skills proposed by experts have the same concept, namely activities that aim to make decisions by considering facts or information (Ennis, 1985a; Halpern, 1999; McPeck, 1981; Facione, 2009). On the other hand, the difference of opinion lies in the scope of the field of science. The first opinion is that critical thinking skills are special in that they can only be applied to one field of science (Halpern, 2003; McPeck, 2017; and Johnson; Siegel, 2010).

While the second opinion is that critical thinking skills are general, namely this ability is general and can be applied in various fields of science (Ennis in Mason, 2009; Paul, Elder, 2014; Facione, 2009).

Among the opinions of general critical thinking skills, critical thinking skills conceptualized by Ennis were chosen as the basis for training students. This is because Ennis' opinion is relevant to the learning curriculum in higher education, namely students are provided with various types of courses or not single courses. The concept of critical thinking developed by Ennis (1985) strengthens the purpose of education, namely to achieve mastery of concepts or fields of science (Law No. 12 concerning Higher Education, 2012). The critical thinking concept developed also supports the achievement of the KKNI, namely for a bachelor's degree equivalent to qualification level 6 which contains decision making by considering various information (Presidential Regulation of the Republic of Indonesia 2012 Number 8 of 2012).

Many learning models have contributed to improving critical thinking skills. However, critical thinking skills in the advanced clarification component are not yet fully optimal. The learning models are problem-based learning or PBL (Mundilarto & Ismoyo, 2017; Awan *et al*., 2017), project-based learning models or PjbL (Sumarni & Kadarwati, 2020; and Taufiq *et al*., 2020), inquiry learning models or IBL (Irwanto *et al*., 2018; Zain & Jumadi, 2018; Herawati *et al*., 2020; Pursitasari *et al*., 2020; Prayogi & Verawati, 2020), learning model Structuring a new Socioscientific Issues (Davut Gul & Akcay, 2020) and the FERA learning model, namely Focus, Explore, Reflect and Apply (Diani *et al*., 2020).

Among the various learning models that have contributed to improving critical thinking skills, but have not been optimal in the advanced clarification component, the inquiry learning model was chosen as the basis for developing CLM. This is due to the Basic Physics Subject Learning Outcomes (CPMK) where students can understand the basic concepts of engineering physics to develop their application in the field of informatics. The Inquiry Model is relevant to the fulfillment of the Basic Physics CPMK, because this model was developed as a basis for strengthening the concept, namely Inquiry (Arend, 2008; Duke, 1990).

Based on the study of the inquiry learning model as the basis for model development, it was found that the measurement of critical thinking skills in advanced clarification was only limited to two indicators. First, define terms and assess definitions based on appropriate criteria (Irwanto *et al*., 2018; Zain & Jumadi, 2018; Rahmi *et al*., 2019; Herawati *et al*., 2020; Maknun, 2020; Pursitasari *et al*., 2020). The second indicator is identifying unstated assumptions (Irwanto *et al*., 2018; Herawati *et al.*, 2020; Maknun, 2020; and Purwitasari *et al*., 2020). The design of CLM development focuses on all KBK-KL indicators which include assessing phenomena based on the right concept, evaluating a person's line of thought, identifying unstated assumptions, predictive thinking, handling label errors, metacognitive thinking,

CLM development has five syntaxes or phases in learning that is1) orientation learning, 2) investigation, 3) reasoning, 4) clarification and evaluation, and 5) reflection. CLM was developed based on constructivism learning theory (Changwong *et al*., 2018; Ray, 2002), intellectual development learning theory, namely students are included in the formal operational category (Slavin, 2011; and Arend, 2008), discovery learning theory is characterized by student learning activities (Slavin, 2011), social constructivism theory is the importance of Zone of Proximal Development (ZPD) in learning (Moreno, 2010:88), meaningful learning theory is expanding information through association (Moreno, 2010; Slavin, 2011), and metacognition theory, namely planning, monitoring and evaluating learning activities independently (Arend, 2008).

The five syntaxes are based on model development theoryArend, (2008)contains four special characteristics that can be used to achieve learning objectives, namely 1) theoretical rationale and logical design 2) learning objectives from the developed model, 3) teaching behavior is needed so that learning can be carried out and 4) learning environment needed to achieve learning objectives, and Joyce *et al*., (2009) there are five components mainin the development of the model, namely 1) syntax, 2) social system, 3) reaction principle, 4) support system, 5) instructional impact and accompaniment impact.

KThe strength of supporting theory and analysis based on learning needs, CLM will be a valid, practical and effective model to improve critical thinking skills in the advanced clarification component. The detailed framework for thinking is shown in Figure 2.4.

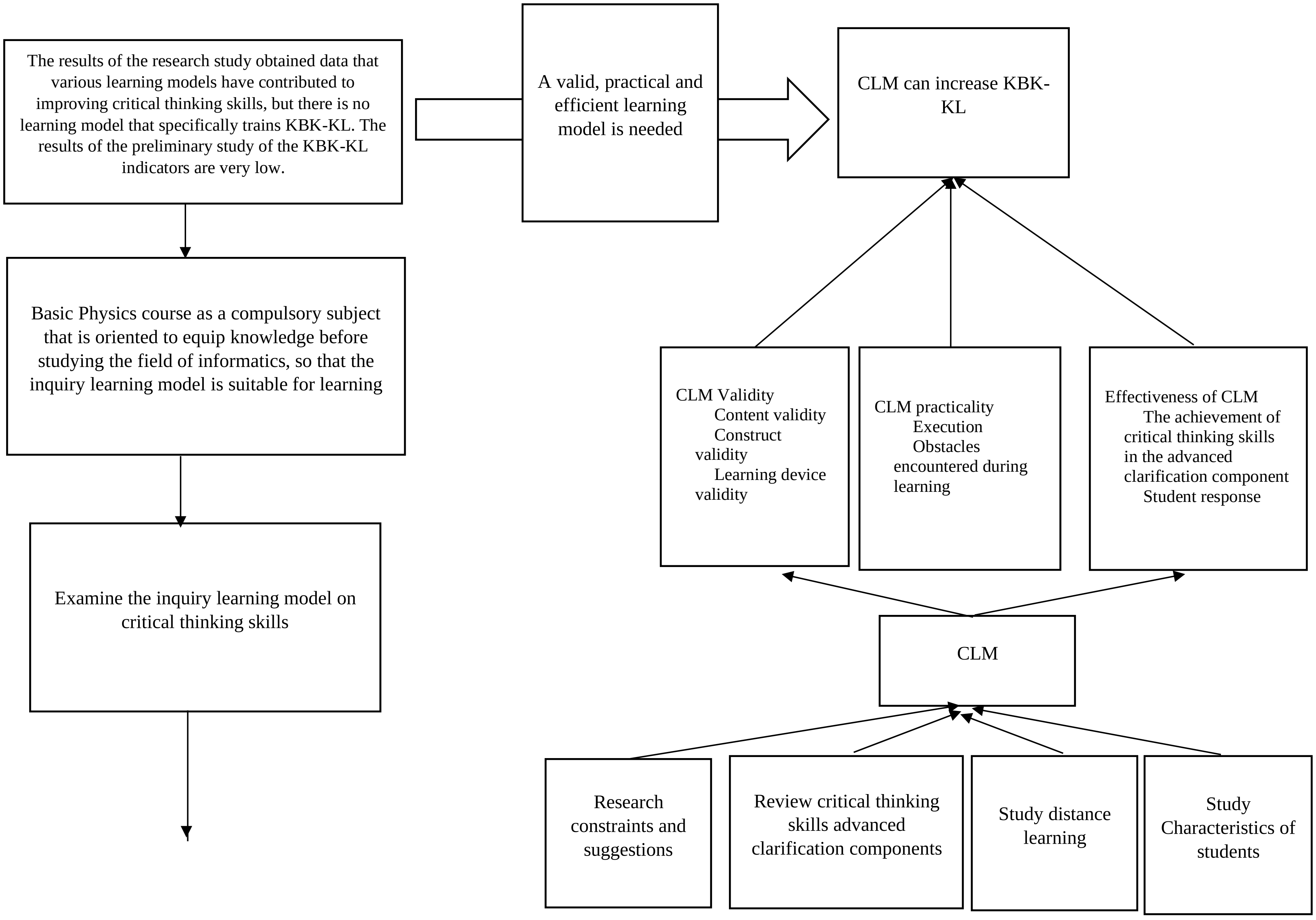


Figure 2.4 CLM Development Framework for

CHAPTER III

RESEARCH METHOD

A. Types of research

The research method uses*Generic Design Research Model* (GDRM) which has 5 stages, namely problem identification, identification of tentative products and design principles, prototyping and assessment of preliminary products and theories, and, problem resolution and Advancing theory. Plomp, and Nieveen, (2013: 11) state that GDRM is a research method used to produce certain products and test the effectiveness of the resulting products. This study aims to develop CLM and its tools which include lesson plans, SAP, student textbooks, student response questionnaires and critical thinking ability test instruments for advanced clarification.

B. Subject, Time and Place of Research

The subject of this research is CLM and its devices. Subjects were tested on a limited scale and on a broad scale using a purposive sampling technique, namely choosing a study program that is included in the Vocational Education and Information Technology sub-cluster that specifically has Basic Physics courses in its curriculum. The details of the limited-scale and broad-scale tests of CLM and its equipment are shown in Table 3.1.

Table 3.1 Details of Limited-Scale and Broad-Scale Tests of CLM and Its Devices

Types of CLM Tests and Devices	**Time**	**Research Place**
Limited Scale	September to October 2021	Informatics Education Study Program, Trunojoyo University, Madura
Wide scale	December 2021 to January 2022	Informatics Education Study Program, Trunojoyo University, Madura Information Technology Education Study Program, University of Lampung IVET Semarang University Informatics Education Study Program

C. Research Stages

Research model design according to *Generic Design Research Model* (GDRM)which has research stages (1) Problem identification, (2) Identification of tentative products and design principles, (3) Tentative products and theories, (4) Prototyping and assessment of preliminary products and theories, and (5) Problem resolution and advancing theory (Plomp & Nieveen, 2013). The explanation of each stage is as follows.

1. *Problem Identification*

Problem identification is based on literature or theory, and site visits. In this step, the researcher conducts a literature and theory study by studying the study to be studied. In the process of developing learning models to improve the KBK-KL

At this stage the researchers conducted a literature study both theoretically and empirically through research results that were relevant to the big theme, namely KBK-KL.

Many learning models have contributed to improving critical thinking skills. However, the critical thinking skills developed by Ennis (2016) on the advanced clarification component are not yet fully optimal. The learning models are problem-based learning or PBL (Mundilarto & Ismoyo, 2017; Awan *et al*., 2017), project-based learning models or PjBL (Sumarni & Kadarwati, 2020; Taufiq *et al*., 2020), inquiry learning models or IBL (Irwanto *et al*., 2018; Zain & Jumadi, 2018; Herawati *et al*., 2020; Pursitasari *et al*., 2020; Prayogi & Verawati, 2020), Structuring a new Socioscientific Issues learning model (Davut Gul & Akcay, 2020) and the FERA learning model, namely Focus, Explore, Reflect and Apply (Diani *et al*., 2020).

This problem is also supported by the results of a preliminary study using survey techniques. The subjects studied were60 students of informatics education at Trunojoyo University, Madura. The timing of the survey was on 17-18 December 2020 using an adaptation of the test instrument (Pradana *et al*., 2017). The results of the analysis of the test work concluded that the students' critical thinking ability on advanced clarification were only able to achieve an average score of 32.1 with a very less critical category. Thus, the KBK-KL indicators are still not optimal. CLM and its tools are used to improve the KBK-KL.

2. *Identification of Tentative Products and Design Principles*

Based on the literature review and the results of the preliminary study, the researchers designed a focused learning model to improve advanced critical thinking skills. The main objective of developing the model is to improve critical thinking ability on advanced clarification as a provision to prepare professionals (Law on Higher Education No. 12 of 2012). The KBK-KL indicators measured include assessing phenomena based on appropriate concepts, evaluating one's line of thought, identifying unstated assumptions, predictive thinking, handling error labels, metacognitive thinking, and solving problems sequentially (Ennis, 2016). A complete explanation of the seven Indicators is described in Table 3.2

Table 3.2 KBK-KL Operational Indicators and Definitions

Indicator	Operational definition
Assess phenomena based on appropriate concepts	Students can identify the right terms for certain phenomena and explain these terms based on the appropriate criteria.
Evaluating a person's line of thought, identifying unstated assumptions,	Students can justify someone's misunderstanding through scientific explanations.
Identify unstated assumptions.	Students can identify the assumptions that cause certain facts/data.
predictive thinking,	Students can predict the possibility that will occur based on the analysis of a number of information.
Handle label errors,	Students evaluate someone's claim, then submit the evaluation results in detail based on factual information
metacognitive thinking,	Students set strategies to achieve certain goals.
Complete Problem in order	Students are able to design a problem-solving process sequentially and then implement it.

Table 3.2 is the seven indicators that will be trained during the learning process to students. In order to be optimal, it is necessary to analyze the problem. Based on the results of the study, the main problem is the difficulty in connecting between the concepts and problems given (Pradana & Parno, 2017; Herunata *et al*., 2020; Sumarni & Kadarwati, 2020). The main keyword is that training and guidance can improve critical thinking skills, so they will be trained through reasoning tasks. As the results of research by Saputro *et al*., (2020) can improve critical thinking skills.

Based on the study of the results of the inquiry model research, one of the models that contributes to improving critical thinking skills, and is relevant to CPMK physics, is used as the main basis for model development. Various obstacles and research suggestions will be taken into consideration in developing the model. So that a hypothetical research model was found with the nameCLM which has syntax or learning phase: (1) orientation learning, (2) investigation, (3) reasoning, (4) clarification and evaluation, and (5) reflection. CLM development will be tested for effectiveness, practicality, and effectiveness.

3. ***Tentative Products and Theories***

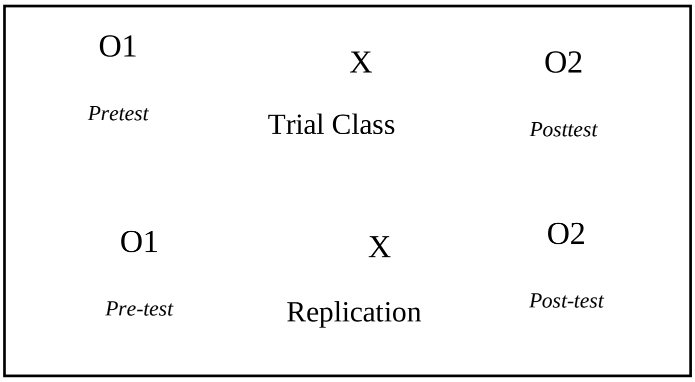
In this step, the researcher designed a prototype 1 CLM which includes model components which include: 1) model syntax, 2) social system, 3) reaction principle, 4) support system, 5) instructional impact. The developed model design is realized in the form of a CLM Model Book. Researchers developed learning tools which included: Semester Learning Plan (RPS), Learning Event Unit (SAP), Student Textbooks, Student Response Questionnaires, Critical Thinking Skills Test for advanced clarification.

The learning tools developed were validated by experts using validation instruments. The model design was developed to be realized in the form of a model book and then validated by experts in a discussion forum commonly called Focus Group Discussion (FGD). The FGD discussed the validity of the theoretically developed learning model which includes model components, namely: i) supporting theory, ii) syntax, iii) social system, iv) reaction principle, v) support system, vi) instructional impact and accompaniment impact. Revision of FGD results resulted in 2 CLM prototypes.

4. *Prototyping and Assessment of Preliminary Products and Theories*

The results of the limited test will be used for evaluation and revision of the products and theories that have been developed. The next step is the implementation of the CLM model is tested on a limited basis. The implementation of the hypothetical model in a limited trial was carried out in two classes so that the Prototype 3 CLM learning model was produced with the following characteristics: i) model validity, model difficulty level, and readability of model supporting devices; ii) the practicality of the model which includes the implementation of the learning model in the classroom, student activities, and the obstacles faced; iii) the effectiveness of the model which includes increasing critical thinking skills, advanced clarification and student responses to the implementation of CLM.

Limited trial using the principle of one group pretest posttest design (Sugiyono, 2012). This principle is the application of a single learning model with a replication class (the replication class, one group pretest and posttest design) without using a control class (Fraenkel, 2009). The research was conducted at the Informatics Education Study Program, Trunojoyo University, Madura in the 2021/2022 academic year by taking two classes, the first class as a trial and the second class as a replication class of the Clarity Learning model.



Picture 3.1 Replication Class Schema, One Group Pre-test-Pos-Test Design

X = LearningCLM is equipped with tools.
O1 = Initial test (*pre-test*) KBK-KL before CLM lessons
O2 = Final test (*post-test*) KBK-KL before CLM lessons

The main assessment instruments and supporting data used in trial 1 are detailed in Table 3.3.

Table 3.3 Limited Trial Research Instruments

01 *(Pre-test)*	X (Clarity Learning Models and Devices)	O2 (Post-test)
KBK-KL Test Instruments.	1. Observation sheet instrument implementation CLM. 2. Observation sheet instrument learning constraints.	1. KBK-KL Test assessment instrument. 2. Student response questionnaire Instrument

Based on the implementation of a limited trial will be able to evaluate the advantages and disadvantages of prototype 2 CLM. Revisions will be developed based on the weaknesses that emerged during the implementation of prototype 2 CLM. Based on the revisions carried out, the prototype 3 CLM was obtained.

5. *Problem Resolution and Advancing Theory*

This process refines the prototype 3 results from the limited test. After going through the evaluation process of any existing weaknesses and problems, new products and theories will be formed with validity that can be accounted for by researchers. The prototype 3 CLM was then implemented in a wide-scale test. In the large-scale trial, the final characteristics were obtained as follows: i) the validity of the model, the level of difficulty of the model, and the readability of the model supporting devices; ii) the practicality of the model which includes the implementation of the learning model in the classroom, and the obstacles faced; iii) the effectiveness of the model which includes increasing the KBK-KL and student responses to the implementation of CLM.

The large-scale test also uses the replication class design, one group pretest and posttest design, namely the class uses a single learning model intervention with a replication class, without using a control class (Fraenkel, 2009). The broad-scale test involves two universities selected purposely with a representative distribution (Riduwan, 2010: 40). The CLM was tested at the Informatics Education Study Program at Trunojoyo Madura University, the Information Technology Education Study Program at the University of Lampung, and the IVET University Informatics

Education Study Program for the 2021/2022 academic year. Each college takes two classes, the first class as a test class and the second class as a CLM replication class as Figure 3.1

O1	X	O2
Pretest	Trial Class	*Posttest*
O1	X	O2
Pre-tes	Replication	*Post-test*

Figure 3.1 Replication class scheme, one group pre-test-post-test design

X = LearningCLM is equipped with tools.
O1 = Initial test (*pre-test*) KBK-KL before CLM lessons
O2 = Final test (*post-test*) KBK-KL before CLM lessons

The main and supporting variables research instruments used in the second trial are detailed in Table 3.4.

Table 3.4 Broad-Scale Test Research Instruments

01 *(Pre-test)*	X (Clarity Learning Models and Devices)	O2 (Post-test)
Critical thinking ability assessment instrument for advanced clarification.	1. The instrument for observing the implementation of the Clarity Learning model 2. Student Activity Sheet 3. Observation sheet instrument learning constraints.	1. Critical thinking ability assessment instrument for advanced clarification. 2. Student response questionnaire Instrument

Broadly speaking, the stages of developing a hypothetical model are as shown in Figure 3.2:

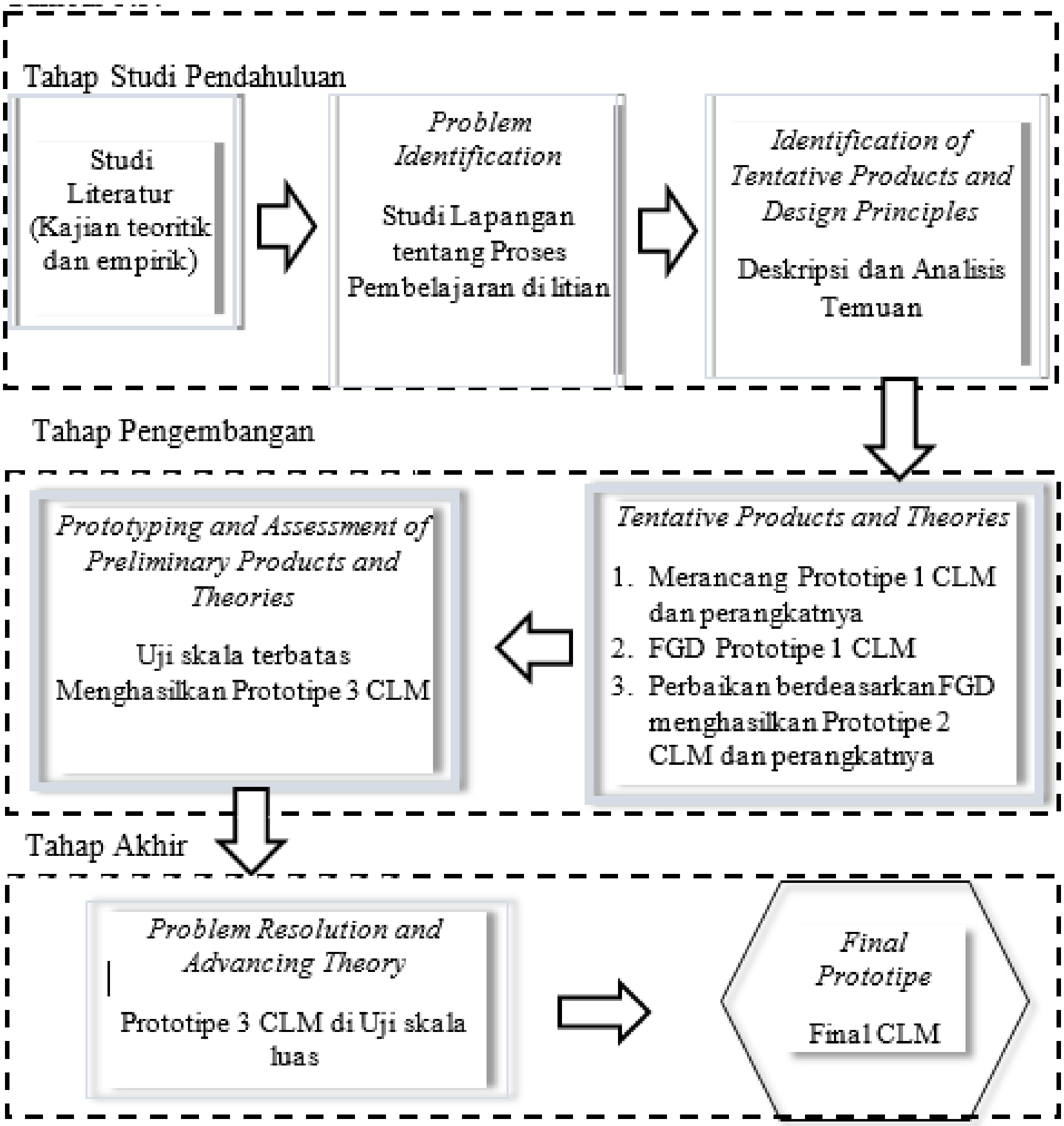


Figure 3.2 Stages of CLM Development Research

D. Variable Study

The variables related to this study include (1) the validity of the CLM model and device; (2) the practicality of CLM; and (3) the effectiveness of CLM. The details of each variable are as follows:

1. Model Validity Variables and Clarity Learning Model Devices

In detail, the variables of the validity of the CLM model and device include three parts, namely:

a. CLM content validity.
b. CLM constructs validity.
c. Content and construct validity of learning tools supporting CLM.

2. Variable Practicality Clarity Learning Model

In detail, the practicality of CLM variables includes three parts, namely:

a. Semester Learning Plans (RPS) and Learning Program Units (SAP).
b. The obstacles that arise in the implementation of CLM.

3. Variable effectiveness of Clarity Learning Model

In detail, the variables of CLM effectiveness include three parts, namely:

a. KBK-KL students
b. Student response

E. DefinitionVariable Operation

The research variables that have been defined in detail are described in the operational definition. Each variable is defined as follows:

1. CLM Validity Variables and their supporting tools

Each part of the validity of the CLM and its supporting tools are defined operationally for ease of measurement. The details are described as follows:

a. CLM content validity is the quality of the model in terms of the needs for Clarity Learning model development, state of the art, CLM theory support, CLM design and implementation, CLM learning environment, and use of evaluation techniques. The CLM content validation score was obtained from the assessment of three experts using the CLM content validation sheet instrument. The model criteria are declared valid if the average score of each expert is at least 2.60 (Ratumanan & Laurens, 2006; and Akhdinirwanto *et al*., 2020).

b. The construct validity of CLM is the quality of the model in terms of the rational aspect of the model and syntax, social systems, reaction principles and model support systems, instructional impact and model accompaniment impact, model classroom management learning environment, implementation of model evaluation. The CLM construct validation score was obtained from the assessment of three experts using the CLM construct validation sheet instrument. The model criteria are declared valid if the average score of each expert is at least 2.60 (Ratumanan & Laurens, 2006; and Akhdinirwanto *et al*., 2020).

c. Content and construct validity of learning tools supporting CLM. Content validity is the quality of the learning tools developed to meet the target characteristics of CLM. Then for the construct validity of the learning device, namely: quality learning tools seen from the linkage of learning device components with CLM characteristics. is the quality of learning tools with CLM which includes Semester Program Plans (RPS), Learning Program Units (SAP), Student Textbooks (BAM). The learning device validation score was obtained from the assessment of three experts using the CLM device validation sheet instrument. The device criteria are declared valid if the average score of each expert is at least 2.60 (Ratumanan & Laurens, 2006; and Akhdinirwanto *et al*., 2020).

2. CLM Practicality Variables

Each part of the CLM practicality variable is defined operationally to simplify the measurement process. The details are described as follows:

a. The implementation of CLM is an actual learning activity (actual practicality) based on a learning scenario designed on the Clarity Learning model. The implementation of CLM learning was assessed using an observation sheet on the implementation of learning which was filled out by two observers. At the time of synchronous observers can directly assess the CLM learning process. The learning model implementation score was obtained from the average score of two observers at least 2.50 with good category (Ratumanan & Laurens, 2006; and Akhdinirwanto *et al*., 2020).
b. Constraints are research constraints that contain discrepanciesAmonglearning activities with a predetermined plan. Factors that cause obstacles such as examples of unexpected obstacles in infrastructure, limited time available, and other things that have the potential to hinder learning activities effectively.*synchronous*. At the time of learning synchronous observers can provide notes through online direct observations. The research constraint findings were recorded by two observers in the CLM model constraint sheet.

3. CLM Effectiveness Variables.

Each part of the CLM effectiveness variable will be defined operationally to make it easier to measure. The details are described as follows.

a. Advanced Clarification Component Thinking Ability

KBK-KL is measured by a test instrument that has been checked for validity by experts. As forKBK-KL indicators are assessing phenomena based on appropriate concepts, evaluating a person's line of thought, identifying unstated assumptions, predictive thinking, handling label errors, metacognitive thinking, n complete problem in order. CLM can be categorized as effective if: 1) the N-Gain of critical thinking ability on advanced clarification is in the medium category 2) the statistical test results for the increase in N-Gain show that there is no difference in all classes given CLM intervention. 3) the average minimum KBK-KL score is in the moderately critical category (Akhdinirwanto *et al*., 2020; Seruni *et al*., 2020).

b. Student response

Student responses are students' opinions and responses to learning activities which are measured using student response questionnaires. The indicators to be measured are the responses of metacognitive abilities in learning such as (planning, controlling and evaluating), information confidence after following the lesson, reasoning ability (concludes based on variable relationships), the ability to explain in more detail, opinions related to textbooks, the ability to present information in a detailed manner. effective, interested in the learning process and atmosphere. The effectiveness of student responses after learning is minimal in the strong category (Riduwan, 2010).

F. TechniqueData collection

Data collection techniques are used to obtain materials that are relevant, accurate, and can be used appropriately according to the research objectives. Data collection techniques used in this study were: expert assessment methods, observations, tests, documentation, and questionnaires. The details are described as follows.

1. Expert Assessment Method

The expert assessment method was used to obtain data on the validity of CLM and its tools. CLM and its tools were validated by three experts in a Focus Group Discussion (FGD) activity. Materials that were validated by experts consisted of validation instruments, CLM model books and RPS tools, SAP, Student Textbooks, Response Questionnaires, and KBK-KL Test instruments which were given by experts two weeks before the FGD was held.

2. Observation

The observation method was used to collect data about the practicality of CLM. Before the observer performs the task of collecting data, it is necessary to have a discussion beforehand to gain an understanding of the observations to be made. This activity is carried out in order to obtain objective and accurate data. Observations were made by two people to assess the practicality of CLM which consisted of the implementation of CLM using the CLM implementation observation sheet instrument, the obstacles to the implementation of CLM learning would be recorded in the learning constraint sheet.

3. Test

The test method was used to collect data about the effectiveness of the CLM model. Tests were given to students consisting of pretest and posttest according to the indicators and objectives developed by the researcher. The test is used to measure or find out the contribution of the learning modelCLMon increasing the capacity of KBK-KL

4. Documentation

Documentation technique to find data regarding: student names as research subjects, student test scores before and after learning, as well as other necessary supporting data.

5. Questionnaire

The questionnaire method was used to collect student response data after participating in learning using CLM. Students are asked to agree on every question they experience and this is done by marking a checklist. Student response questionnaires were given at the end of the learning activities.

G. Instrument of Study

Based on the explanation of operational definitions of research variables and data collection techniques, an instrument is needed as data collection material. The research instrument in detail is described as follows.

1. CLM Validity Instrument

CLM validity instruments are divided into three types. Each type of instrument is described as follows:

a. **CLM Content Validity Sheet**

The CLM content validity sheet is prepared based on the criteria set in the operational definition. The basis for developing this instrument is the need for CLM development (needs), state of the art knowledge, CLM planning and implementation, CLM learning environment, and the use of content validity sheet evaluation techniques will be measured by three experts with a scale used by the rating model. scale, the expert did not answer in the form of a qualitative choice that had been provided, but answered with a quantitative choice from a score of 1 to a score of 4.

b. **Clarity Learning Model Construct Validity Sheet**

The CLM construct validity sheet is prepared based on the criteria set out in the operational definition. The basis for developing this instrument is the rational aspect of the model and syntax, social systems, reaction principles and model support systems, instructional impact and model accompaniment impact, classroom management learning environment model, implementation of model evaluation. The construct validity sheet will be measured by three experts with a scale used by the rating scale model, the expert does not answer in the form of qualitative choices that have been provided, but answers with a quantitative choice score of 1 to a score of 4.

c. **Content Validity Sheet and Clarity Learning Model Toolkit**

Content and construct validity sheets for CLM supporting tools are prepared based on the criteria set out in the operational definition. The basis for developing this instrument includes RPS, SAP, Student Textbooks (BAM) and the KBK-KL

Test. The construct validity sheet will be measured by three experts with a scale used by the rating scale model, the expert does not answer in the form of qualitative choices that have been provided, but answers with a quantitative choice score of 1 to a score of 4.

2. CLM Practical Instruments

CLM practicality instruments are divided into three types. Each type of instrument is described as follows:

a. **Learning Implementation Observation Sheet**

The CLM learning implementation observation sheet is an instrument used to measure actual learning activities (actual practicality) based on CLM learning scenarios. During Synchronous, observers can directly assess the learning process, or record messages on the streaming channel of each group of students. The observation sheet for the implementation of learning will be measured by two observers with a choice of scale used by the rating scale model, the observer does not answer in the form of qualitative choices that have been provided, but answers with a quantitative choice of scores of 1 to 4.

b. **CLM Learning Constraint Sheet**

The CLM constraint sheet is an instrument that is used to determine research constraints, namely notes on discrepancies between learning activities and the predetermined plan. This can happen due to, among other things, unexpected infrastructure, limited time available, and other things that have the potential to hinder learning activities. The CLM constraint sheet will be filled out by two observers in the form of descriptive notes, as study material to improve the quality of CLM learning.

3. CLM Effectiveness Instruments.

CLM effectiveness instruments are divided into two types. Each type of instrument is described as follows:

a. KBK-KL test

The KBK-KL test is an instrument used to measure the effect of CLM on the increase in KBK-KL test indicators are assessing phenomena based on appropriate concepts, evaluating one's line of thought, identifying unstated assumptions, predictive thinking, handling error labels, metacognitive thinking, and solving problems sequentially. KBK-KL a test will be given to all students who receive CLM intervention.

The validity of the KBK-KL test was obtained from the results of the FGD by 3 expert validators. The aspects assessed by the three validators include clarity, content accuracy, unbiasedness and language use. The average result of the total validity of the test obtained a score of 3.8 which is included in the very valid category (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006). While the percentage of agreement of 93% is included in the reliable category (Akhdinirwanto *et al*., 2020; Borich, 1994). Thus, the KBK-KL test is valid and can be used as a measurement of the increase in students' KBK-KL in physics courses. Details of the calculations are in appendix 5 of the results of the test validity assessment.

b. Student Response Questionnaire

Student response questionnaire is an instrument used to determine student opinions and responses to learning activities. The first indicator that will be measured is the response related to learning tools that have been compiled in student textbooks. Second, students' responses to the CLM learning atmosphere. Third, responses related to learning objectives are self-confidence in mastering the KBK-KL. Student response questionnaire will be given to all students after participating in CLM learning at the end of the meeting.

The validity of the student response questionnaire was obtained from the results of the FGD by 3 expert validators. The aspects assessed by the three validators include clarity, content accuracy, unbiasedness and language use. The average result of the total validity of the test obtained a score of 3.8 which is included in the very valid category (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006). While the percentage of agreement of 95% is included in the reliable category (Akhdinirwanto *et al*., 2020; Borich, 1994). Thus, the student response questionnaire is valid and can be used as a measurement of the increase in student KBK-KL in physics courses. Details of the calculations are contained in Appendix 6 of the results of the assessment of the validity of the student response questionnaires.

H. Data analysis technique

The data that has been obtained using research instruments in the form of the validity of the CLM instrument and its tools, the practicality of the CLM, and the effectiveness of the CLM were analyzed with the right technique. The data analysis techniques for each research variable are explained as follows.

1. CLM Validity Data Analysis and Its Tools

The validation results of the three experts will be processed using quantitative and qualitative descriptive techniques. Quantitative descriptive is to calculate the average score of each expert and then describe it based on predetermined criteria. While qualitative, namely analyzing the notes of each expert in the comment's column. The data obtained from filling in when the expert will be measured for validity and reliability.

The validity of the CLM and its tools obtained the results of calculating the average value of each expert in detail in Table 3.5.

Table 3.5 Criteria for Categorizing Content Validity Assessment, CLM Constructs and Tools

Score Interval	Rating Category	Information
3.6 P 4	Very valid	Can be used without revision
2.6 P 3.5	Valid	Usable with minor revisions
1.6 P 2.5	Not valid	Can be used with multiple revisions
1 P 1.5	Invalid	Can't be used yet and still need consultation

(Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006)

The reliability of content validity, construct validity, CLM and its tools are obtained by calculation results using the following equation:

$$\textit{Percentage of agreement} = \left[1 - \frac{A-B}{A+B}\right] x\ 100\%$$

Information:

A : the frequency of the component aspects of content validity, constructs and tools assessed by experts who provide high frequency.

B : the frequency of the component aspects of content validity, constructs and tools assessed by experts who gave low frequency.

Based on the results of the calculation of reliability, content validity, CLM constructs and tools can be categorized as reliable if it has a percentage of 75% (Akhdinirwanto *et al*., 2020; Borich, 1994).

2. CLM Practical Analysis

The practicality of CLM was obtained from filling out the CLM implementation sheet instrument, and the constraint sheet by two observers. The results of filling out the three instruments have different analyses in their processing as follows.

a. **CLM Implementation Analysis**

The analysis of the implementation of the Clarity Learning Model uses descriptive quantitative data processing that has been filled in by two observers, each observer will be calculated and then described the criteria. The data calculation for each observer uses the following equation:

$$P = \frac{Score\ obtained}{Total\ score}$$

The results of data entry by observers will be searched for the average value and then interpreted in a qualitative understanding in the form of categories as shown in Table 3.6.

Table 3.6 CLM Implementation Categorization Criteria

Score interval	Category
1.00-1.49	Not good
1.50-2.49	Not good
2.50-3-49	Well
3.50-4.00	Very good

(Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006)

Meanwhile, CLM can be said to be practical on the implementation of learning for each observer at least with a score of 2.50 with a good category (Ratumanan & Laurens, 2006).

The reliability of the implementation of CLM is obtained by calculating the results using the following equation:

$$\textit{Percentage of agreement} = \left[1 - \frac{A-B}{A+B}\right] x\ 100\%$$

Information:

A : the frequency of model implementation aspects observed by observers who give a high frequency.

B : the frequency of model implementation aspects observed by observers who give a low frequency.

Based on the calculation results, the implementation of CRM can be categorized as reliable if it has a percentage of 75% (Akhdinirwanto *et al.*, 2020; Borich, 1994).

b. **Analysis of Research Obstacles**

Constraints during the learning process were obtained using the research constraint sheet data that had been filled out by the two observers. The results of the notes on the constraint sheet were analyzed by qualitative descriptive, namely describing the results of the notes of observers and researchers during the implementation of CLM.

3. Analysis Effectiveness CLM

The analysis of the effectiveness of CLM consists of increasing the KBK-KL and student responses.

a. **KBK-KL Improvement Analysis**

Analysis of the average KBK-KL data for all indicators was obtained from the results before (pretest) and after (posttest) then calculated the increase in KBK-KL with normalized N-Gain with the equation:

Normalized gain (N-Gain)=$\frac{End\ Score - First\ Score}{Maximum\ Score - Firts\ Score}$

Then it is converted based on the criteria in Table 3.7 as follows:

Table 3.7 Normalized Gain Criteria

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

(Hake, 1999)

CLMcan be categorized as effective if the level of attainment of N-Gain is at least in the medium category. The consistency of increasing critical thinking skills in the KBK-KL will be checked on the results of the limited-scale test and the wide-scale test. Increase the level of critical thinking skills, both the total KBK-KL indicators and each KBK-KL indicator use equality:

$$P = \frac{Score\ Obtained}{Maximum\ Score}\ x\ 100\%$$

The percentage results are then categorized into five levels ranging from very less critical, less critical, moderately critical, critical, very very critical (Seruni *et al.*, 2020). CLMcan be categorized as effective if the level of ability is minimal critical thinking in the moderately critical category.

Table 3.8. Category of Critical Thinking Ability

Score	Category
90% < X < 100%	Very Critical

75% < X < 90%	Critical
55% < X < 75%	Critical Enough
40% < X < 55%	Less Critical
0% < X < 40%	Very Less Critical

1) Increase in KBK-KL on Limited-Scale Test

The consistency of the increase in KBK-KL on a limited scale test using a t-test (t-test) with the type of independent sample t-test using SPSS. The purpose of this test is to determine whether or not there is a difference in N-Gain in the two groups that have attended CLM learning at a significance level of = 0.05 provided that the N-Gain score comes from a normal and homogeneous population (Siregar, 2015). Thus, the normality and homogeneity will be tested first using SPSS.α

In testing the hypothesis using the independent sample t-test, the significance level = 0.05 (2 tailed). The test hypothesis is as followsα

HO : no difference*N-Gain*KBK-KL is significant both in the first group and in the second group after participating in CLM learning
HA : there is a significant difference in the KBK-KL N-Gain both the first and second groups after participating in CLM learning

The criteria for rejecting H0 based on the P-value (in SPSS version 17 program the significance "sig") is used are as follows:

If P-value < , then H0 is rejectedα

If P-value > , then H0 is accepted.α

IfscoreThe normalized N-Gain score is not normally distributed, so to find out whether there is a difference as a basis for the consistency of increasing critical thinking skills, advanced clarification uses the Mann-Whitney Test.

2) Increase in KBK-KL on Broad-Scale Test

Consistency Increase Critical thinking ability on advanced clarification on the wide-scale test using ANOVA with the type of one-way ANOVA test using SPSS version 17. The purpose of this test is to determine whether or not there is a difference in N-Gain for more than two groups that have received CLM learning at a significance level of 0.05 with the condition that the N-Gain score comes from the population. normal and homogeneous (Siregar, 2015: 157-163). Thus, the normality and homogeneity will be tested first using SPSS version 17.α

In testing the hypothesis using one way ANOVA, the significance level = 0.05. The test hypothesis is as follows:α

HO : no difference*N- gain*KBK-KL is significant for all groups after participating in CLM learning

HA : there is no significant difference in the N-gain of KBK-KL in all groups after participating in CLM learning

The criteria for rejecting H0 based on the P-value (in the SPSS program the significance “sig”) is used are as follows:

If P-value < , then H0 is rejectedα

If P-value > , then H0 is accepted.α

If the normalized N-Gain score is not normally distributed, then to determine whether there are differences in all groups as the basis for the consistency of the increase in KBK-KL using the*Kruskal Wallis Independent Sample K Test*

3) Analysis of Each Critical Thinking Ability Indicator Advanced Clarification

Each question indicator will be analyzed using the N-Gain value. The calculation results the score of each indicator both pretest and posttest then calculated the increase in critical thinking ability on advanced clarification with normalized N-Gain.

Then converted based on the criteria in Table 3.7. Every indicator can be categorized as effective if the level of attainment of N-Gain is at least in the medium category.

b. **Student Response Questionnaire Analysis**

Data about student responses were obtained from student response questionnaires to learning activities, and then analyzed using quantitative and qualitative descriptive. The response data obtained were used to follow up learning activities using CLM. Analysis of student response questionnaire data will be measured by two observers with a choice of scale used by the rating scale model, students do not answer in the form of qualitative choices that have been provided, but answer with a quantitative choice of score 1 to score 4. Mathematically it can be written as follows:

$$P = \frac{Obtained\ Score}{Maximum\ Score}\ x\ 100\%$$

The percentage of student responses was converted with the following criteria:

Number 0% - 20% = Very weak
Number 21% - 40% = Weak
Number 41% - 60% = Enough
Figures 61% - 80% = Strong
Number 81% - 100% = Very strong

(Riduwan, 2010)

The effectiveness of student responses after learning is minimal in the strong category, namely (60%-80%).

CHAPTER IV

RESEARCH RESULT

A. Results of Clarity Learning Model (CLM) Development

CLM was developed using the Generic Design Research Model (GDRM) research method by Wademan which has the goals of (1) Problem identification; (2) Identification of tentative products and design principles; (3) Tentatives products and theories; (4) Prototyping and assessment of preliminary products and theories; and (5) Problem resolution and advancing theory (Plomp & Nieveen, 2013). The product of this research is CLM and CLM learning tools. Furthermore, the product was tested for validity, practicality and effectiveness to determine the feasibility of CLM and CLM learning tools.

In the first stage, problem identification was obtained through a preliminary study through a literature review on the problem of critical thinking skills and then confirmed through survey techniques. Many learning models have contributed to improving critical thinking skills. However, critical thinking skills in the advanced clarification component (KBK-KL) are not yet fully optimal. The learning models are problem-based learning or PBL (Mundilarto & Ismoyo, 2017; Awan *et al*., 2017), project-based learning models or PjbL (Sumarni & Kadarwati, 2020; Taufiq *et al*., 2020), inquiry learning models or IBL (Irwanto *et al*., 2018; Zain & Jumadi, 2018; Herawati *et al*., 2020; Pursitasari *et al*., 2020; Prayogi & Verawati, 2020),

KBK-KL has not been optimally having results that are relevant to the results of the research survey. The survey carried out onDecember 17-18, 2020 which was attended by 60 students of Trunojoyo Madura University, the results showed that the critical thinking ability component was further clarified, students only able to get the average score32.1. So it can be concluded that students' critical thinking skills in the advanced clarification component are included in the very less critical category (Seruni *et al*., 2020).

The second stage of identification of tentative products and design principles is obtained through research analysis studies related to critical thinking components, advanced clarification and study of critical thinking skills learning theory. The results of the meta-analysis of the low KBK-KL are caused by three main problems. First, learners are still experiencing difficulty in connecting the theory that has been studied with the problem at hand (Sumarni & Kadarwati, 2020). Second, the differences in critical thinking abilities are influenced by the initial abilities possessed by each student (Herunata *et al*., 2020). Third, students find it difficult to do the given test, this is because it is not only solved by mathematical equations, but requires an explanation based on scientific reasoning abilities.(Pradana & Parno, 2017; Sumarni & Kadarwati, 2020; Herunata *et al*., 2020; Herawati *et al*., 2020).

Whereas Suggestions include 1) authentic problems containing puzzles and activities Hypothesis and experimental activities can improve critical thinking skills of advanced clarification components (Mundilarto & Ismoyo, 2017; Kadarwati 2020; Rahmi *et al*., 2019; Diani *et al*., 2020).2) multiple representations help improve critical thinking skills in the clarification component further (Herawati *et al*., 2020).3) Optimizing practice and guidance in working on thinking tests(Diani *et al*., 2020; Herunata *et al*., 2020) and strengthening reasoning (Pradana & Parno, 2017; Sumarni & Kadarwati, 2020; Herunata *et al*., 2020; Herawati *et al*., 2020).Constraints and input from the results of this study will be part of developing the model.

Based on studystudy theory, pLearning to train critical thinking skills requires special designs with various forms of activities, such as analyzing, comparing and other activities (Stephen Johnson; Siegel, 2010). This opinion is reinforced by McPeck (2017), namely the ability to think critically is a skill, so it can be taught through a certain training. Critical thinkers only provide signs for the pattern of teaching critical thinking skills in general, namely learning can be done through a problem-solving process (Ennis, 2015:44; Facione & Gitten, 2016).

Physics Is part of natural science that discusses related natural phenomena that have an impact as science that builds critical thinking, ways of investigation (Koballa, 2010). The concept of physics can be obtained through analytical and observational approaches. Physical products are the result of processes in the form of: facts, concepts, principles, theories, and laws (Ibrahim, 2012). Learning concepts based on the reality that is around us will have an impact on future readiness (BuecheandHecht, 2006). In addition, through mastery of concepts it can be applied for various purposes, through: manipulation or material manipulation through creative ideas (Sayido, *et al*., 2020). Thus, the right theory is needed to train critical thinking skills in Basic Physics courses, including constructivist theory, intellectual development, discovery learning, learning mean, social constructivism, and metacognition theory.

In accordance with CPM subject In Basic Physics, what students need in studying physics is an investigation process. So that the development of the model is done by adopting learning inquiry (IBL) combined with research suggestions, namely strengthening reasoning and optimizing student guided exercises. The findings, both theoretically and in fact, become the basis for tentative products and design principles for developing CLM.

In the second stage, research products are produced in the form of a CLM prototype and CLM learning tools. ProductThe result considers several important aspects, namely the inquiry learning model, constructivist learning theories, student characteristics and distance learning environment, thus forming a conceptual framework for a hypothetical CLM model to improve KBK-KL. The hypothetical model that has been formed is then described in an academic text in the form of a CLM book, anddevices learning in the form of RPS, SAP, and Student Textbooks.

The contents of the CLM book consist of background, CLM model design, CLM model overview, assessment and evaluation. First, the background contains the findings of the problem based on the study of research results, survey of research results and summaries. The second design of the CLM model contains a theoretical basis for model development which includes the importance of critical thinking skills for graduate profiles, critical thinking skills, advanced clarification of critical thinking skills, inquiry learning models, work and energy materials, theory-theory critical thinking learning, student characteristics, and distance learning. The three overviews of the CLM model, consist of the characteristics of the CLM and the components of the CLM model. The characteristics of CLM consist of sub-topics of syntax design rationality, CLM learning objectives, CLM learning management, CLM learning environment. The model component consists of subtree discussion syntax, social system, reaction principle, support system, impact instructional and accompaniment. The four assessments and evaluations consist of assessing the progress of students' KBK-KL abilities through quizzes and reflections. The five summaries contain important points in the development of the CLM book.

The third stage of tentative products and theories contains validation activitiesprototype1 CLM and CLM learning tools. Validation is done through Focus Group Discussion (FGD). FGD aims to discuss the validity of CLM and the theoretically developed CLM tool by three validators. This activity was carried out on August 28, 2021. All inputs during the FGD were recorded and corrected. The results of the improvements were submitted to the three experts (validators) to assess the CLM academic text, Semester Learning Plans (RPS), student textbooks, KBK-KL test instruments, and student response questionnaires.

The results of the CLM validation and CLM learning tools are very valid in terms of content and constructs (detailed descriptions are discussed in Chapter 4 point B). These results indicate that the design of prototype 1 CLM and CLM learning tools are substantially in accordance with the theory of model development and learning tools. However, technically CLM needs some improvements as shown in Chapter 4B Table 4.5.

All inputs by the three validators againstPrototype1 has been corrected by the researcher. Important notes on the CLM model include the use of the LMS and the emphasis of phase-2. By substance all validators agree that LMS is part of the learning media. An important input is the technical use of the LMS. design onPrototype1 LMS has a dual role, namely as a learning medium both before and after learning, namely the provision of teaching materials including RPS, SAP student textbooks, and sending student assignments as well as communication media when learning using zoom meetings. Validator asks for communication media when learning is removed with consideration will narrow learning activities and increase the difficulty of internet access because students open two zoom meetings and LMS applications that run together. In addition, the validator also reminded that phase two was focused on learning objectives.

An important note for learning tools in RPS and SAP is that in the time allocation for the investigation it is necessary to add 5 minutes because in addition to the simulation, presentations must be made. In our opinion, this suggestion is important to follow up because students are still not used to the use of Phet Interactive Simulations in Basic Physics courses. Technically, we reduced the time by 5 minutes for phase 1 and used it as an additional time in phase 2. In addition, there are similarities in notes on RPS, and SAP and student textbooks, namely to add the latest references. Improvements were made by adding three new references, namely two published by Knight, Randal in 2013 and 2017, and one kristanto book in 2019.

The fourth stage is prototyping and assessment of preliminary products and theories in the form of product development testingPrototype2 CLM and a limited CLM Toolkit. This activity will be held from September to October 2021.The purpose of implementing a limited scale test is to determine the practicality, effectiveness of improving critical thinking ability on advanced clarification, as well as evaluating Prototype 2 to produce prototype 3 CLM and CLM tools.

In the fourth stage, the results obtained that CLM and CLM tools are practical and effective to use. However, there are still technical problems that need to be fixed, including the need for optimizing the LMS for pre-learning, and there are still a small number of typing errors in the detailed notes on the constraints contained in the table, and. Improvements to the prototype do not change the CLM syntax, only strengthen the role of the LMS. In Prototype 2 the evaluation results exceeded the time limit because students still needed direct guidance or guidance by the lecturer so that it had an impact on the ineffectiveness of time in phase 2. So, the improvement made was sending simulation practicum videos to students before the zoom meeting started. Improvements in learning tools for writing grammar improvements in student textbooks. Complete notes on problems and improvements are shown in CHAPTER 4.C Tables 4.13 and 4.12. All improvements made are contained in the CLM Prototype 3 and CLM learning toolkit.

The fifth stage is problem resolution and advancing theory. Stages in the form of product testing 3 CLM prototype development and CLM tools widely. This activity will be held from December 2021 to January 2022.The purpose of carrying out a large-scale test is to determine the practicality, effectiveness of improving critical thinking ability on advanced clarification, as well as evaluating prototype 3 to produce a final prototype of CLM and CLM tools.

In the fifth stage, the results obtained that CLM and CLM tools are practical and effective to use. However, there are still technical problems, such as the network, the speed of operation of Phet Interactive Simulations due to the difference in RAM on student laptops and the need to adapt the learning model at the first meeting. A complete note of constraints and improvements is shown in CHAPTER 4.C Table 4.15 All syntaxes run optimally, improvements at this stage are more directed at research suggestions so that other research users in implementing CLM need to pay attention to network factors, optimization of learning motivation, quality of learning interactions, and use laptop with higher ram speed.

The final CLM prototype that has been developed is in the form of a syntax consisting of five phases of learning when synchronous (online meeting) and using LMS when asynchronous. This model facilitates students to develop critical thinking ability on advanced clarification in the Basic Physics course in the study group of the Vocational Education and Information Technology Study Program. Five phases of learning that are owned by CLM when synchronized include (1) Learning Orientation; (2) Investigation; (3) reasoning; (4) Clarification and Evaluation; and (5) Reflection. The use of LMS when asynchronous is used for delivery of teaching materials includes RPS, SAP, Student Textbooks, learning simulation videos, and collection of material summary assignments. The following is an example of an LMS as a delivery of teaching materials as shown in Figure 4.1

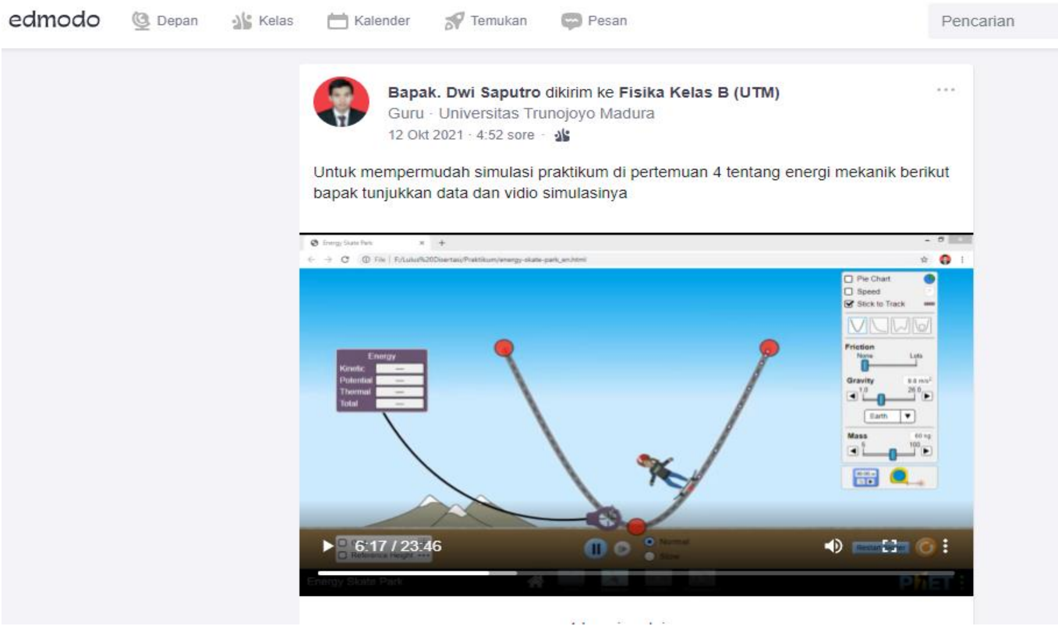


Figure 4.1 The Role of LMS as Delivery of Teaching Materials

The guidelines for implementing CLM activities are shown in Table 4.1. While the example of CLM implementation is described in SAP as Appendix D.2.

Table 4.1 Learning Guide with CLM

CLM Syntax	Lecturer Activities	Student activities
Learning Orientation Phase	The lecturer gives an authentic phenomenon, then asks students to comment on the phenomenon.	Students respond to authentic phenomena given by the lecturer.
	Lecturers convey the relationship of authentic phenomena with learning objectives.	Students listen to the relationship between phenomena and learning objectives.
	The lecturer conveys the learning achievement targets for the subject to students.	Students listen, and know the main targets of learning outcomes that need to be mastered.

CLM Syntax	Lecturer Activities	Student activities
Investigation Phase	The lecturer accompanies a series of investigations ranging from problem formulation, hypotheses, data collection, and conclusions to students and asks students to report the results of their investigations.	Students carry out investigations starting from filling in problem formulations, hypotheses, collecting data and making conclusions. Student representatives present the results of the investigation.
Reasoning Phase	Lecturers appoint student representatives to deliver reasoning exercises, discussions, and discussions. Then give students the opportunity to ask questions if there is something they don't understand.	Students deliver exercises about reasoning and discussion. If students have not been able to master the concept, then students can ask the lecturer directly.
Clarification and Evaluation Phase	Lecturers give quizzes containing exercises on critical thinking skills for further explanation. Lecturers discuss the results of practice questions and provide opportunities for students to ask questions if something is not understood	Students do the exercises that have been given by the lecturer. If students have not been able to master the concept, then students can ask the lecturer directly.
Reflection Phase	Lecturers reflect through summaries made of questions such as what is meant by effort? The lecturer asks students to summarize the material in the form of a mind map diagram.	Students together answer a brief summary of the material questions. Students collect mind map charts in LMS.

Based on Table 4.1, the five phases of the CLM syntax begin with phase-1 learning orientation. It aims to build student interest in learning a learning material through the provision of authentic problems. Then the lecturer relates the phenomenon of authentic problems with learning achievement targets that need to be mastered by students. Continued in phase 2 of the investigation, students in groups conduct simulations to answer authentic phenomena problems. This activity starts from formulating problems, hypotheses, collecting data, delivering and answering authentic phenomena. Phase-3 reasoning, students report the results of the reasoning tasks they have tried to do before learning. Lecturers evaluate the work of reasoning tasks and provide opportunities for students to ask questions. The fourth phase is clarification and evaluation, directly through ppt which is displayed in the zoom meeting of students working on quizzes. Lecturers evaluate quizzes and give students opportunities to ask questions. Lecturers make short questions to check student understanding as well as reflection on learning. Finally, students were asked to make a summary of the material in the form of a mind map chart that was collected through the LMS. The following is an example of proof of student assignment collection through LMS shown in Figure 4.2. Based on Figure 4.2, there are 25 students who have collected assignments given by the lecturer. Lecturers make short questions to check student understanding as well as reflection on learning. Finally, students were asked to make a summary of the material in the form of a mind map chart that was collected through the LMS. The following is an example of proof of student assignment collection through LMS shown in Figure 4.2. Based on Figure 4.2, there are 25 students who have collected assignments given by the lecturer. Lecturers make short questions to check student understanding as well as reflection on learning. Finally, students were asked to make a summary of the material in the form of a mind map chart that was collected through the LMS. The following is an example of proof of student assignment collection through LMS shown in Figure 4.2. Based on Figure 4.2, there are 25 students who have collected assignments given by the lecturer.

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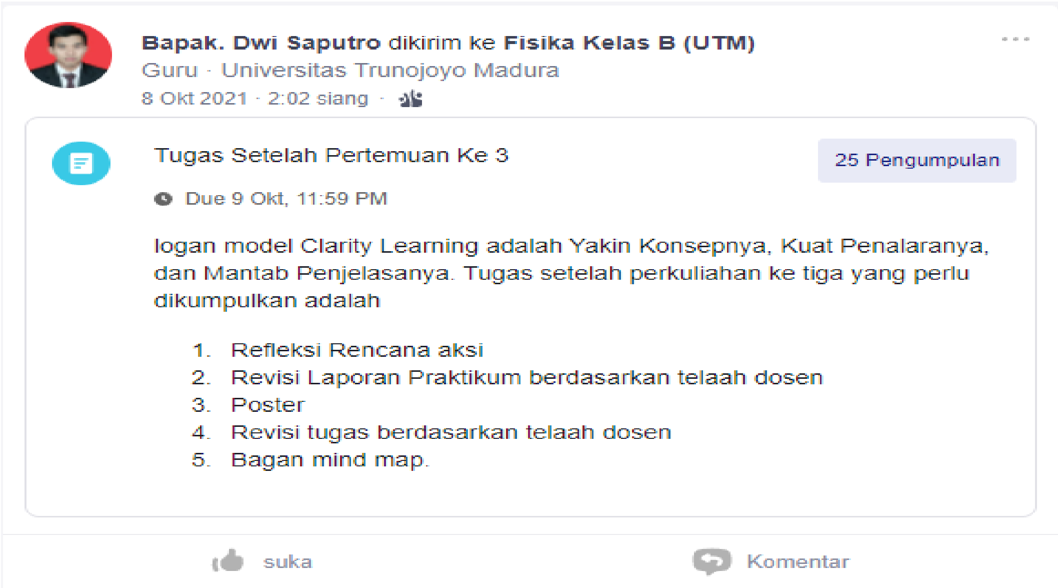

Figure 4.2. Proof of Submitting Student Assignments via LMS

CLM was developed with the aim of training KBK-KL in Basic Physics courses.The seven KBK-KL indicators include defining terms and assessing definitions based on appropriate criteria, handling misunderstandings appropriately, identifying unstated assumptions, suppositional thinking (estimations), handling wrong claims, metacognitive thinking, and solving problems sequentially. The five phases of the CLM syntax in training the seven KBK-KL indicators are shown in Table 4.2.

Table 4.2 The relation of CLM Syntax in training KBK-KL indikator indicators

CLM Syntax	KBK-KL Indicator Target
Phase -1 Learning Orientation	• Metacognitive thinking

CLM Syntax	KBK-KL Indicator Target
Phase-2 Investigation	● Identify unstated assumptions ● Solving problems in order
Phase- 3 Reasoning	● Thinking predictive thinking ● Handling label errors
Phase- 4 Clarification and Evaluation	● Assess phenomena based on appropriate concepts ● Evaluating a person's line of thought
Phase- 5 Reflection	● Metacognitive thinking

Based on Table 4.2, it shows that each phase of the CLM syntax plays a role in training the KBK-KL indicators. Phase-1 learning orientation aims to train KBK-KL on metacognitive thinking indicators. Phase-2 of the investigation aims to train KBK-KL on indicators, identify unstated assumptions and solve problems in order. Phase-3 reasoning aims to train KBK-KL on indicators of predictive thinking and dealing with label errors. Phase-4 clarification and evaluation aims to train KBK-KL on indicators of assessing phenomena based on appropriate concepts and evaluating one's line of thought. Phase -5 reflection aims to train KBK-KL on indicators of metacognitive thinking.

B. CLM Validity and Learning Tools

Data validity KLM, and learning tools obtained through expert assessment methods. The CLM and tools were validated by three experts in a Focus Group Discussion (FGD) activity on August 28, 2021. All input during the FGD was recorded and corrected. The results of the improvements were submitted to the three experts (validators) to assess the CLM academic text, Semester Learning Plans (RPS), student textbooks, advanced clarification critical thinking skills test instruments, and student response questionnaires. Assessment of CLM and CLM tools uses a validation sheet with a rating scale method with a score of 1-4. The results of the assessment of each validator will be averaged and then analyzed with very valid criteria that is used without revisions, valid that can be used with few revisions, less valid that can be used with many revisions, (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006).

1. CLM Validity

DraftThe CLM that has been developed is measured for validity by three validators which include content and construct validity. CLM was developed in the form of an academic text book containing an introduction, CLM model design, CLM overview, assessment and evaluation. The results of the content and construct validity of CLM are described as follows.

Measurement of the validity of the content of CLM using a validity sheet that contains 16 statements with three aspects of assessment. These three aspects include the need for CLM development with 4 statements, state of the art knowledge containing 4 statements, and the learning model component consists of 8 statements. The results of the content validity assessment are shown in Table 4.3. Details of the results of the validity of the content of the CLM can be seen in Appendix A. 1.01.

Table 4.3 CLM Content Validity Assessment Results

No	Validation item	$\underline{V}$	Note:	Reliability	
				R	Note:
1.	Aspects of CLM development needs	3.8	SV	93%	Reliable
2.	Aspects of the latest knowledge (state of the art knowledge)	3.8	SV	97%	Reliable
3.	Model component aspect	3.8	SV	100%	Reliable

Description: = average score of the three validators, R = coefficient of reliability. $\underline{V}$

Based on Table 4.3, the results of the validity and reliability of each aspect of the CLM content validity assessment are obtained. Aspects of the need for CLM development obtained an average score of 3.8 which is included in the very valid category, and a reliability coefficient of 93% is included in the reliable category. Aspects of the latest knowledge (state of the art knowledge) obtained an average score of 3.8 which is included in the very valid category, and a reliability coefficient of 97% is included in the reliable category. Likewise, in the component aspect of the model, an average score of 3.8 is obtained which is included in the very valid category, and a reliability coefficient of 100% is included in the reliable category. Based on the results of the content validity assessment, it can be concluded that the three aspects are included in the very valid and reliable category.

LikeAs well as content validity, the measurement of construct validity of CLM uses a validity sheet which contains 16 statements with five aspects of assessment. The five aspects include an overview of CLM as many as 3 statements, conformity of CLM with theoretical and empirical support as many as 5 statements, planning and implementing CLM as many as 4 statements, CLM learning environment as many as 4 statements, for assessment and evaluation of CLM consists of 2 statements. The results of the construct validity assessment are shown in Table 4.4. Details of the results of the CLM construct validity can be seen in Appendix A. 1.02.

Table 4.4 CLM construct validity assessment results

No	Validation item	V	Note:	Reliability	
				R	Note:
1.	CLM Overview	3.9	SV	96%	Reliable
2.	Aspects of the suitability of CLM with theoretical and empirical support	3.9	SV	97%	Reliable
3.	CLM planning and implementation	3.8	SV	100%	Reliable
4.	CLM learning environment	3.8	SV	93%	Reliable
5.	CLM assessment and evaluation	4.0	SV	100%	Reliable

Description: = average score of the three validators, R = coefficient of reliability V

Based onTable 4.4 shows the results of the validity and reliability of each aspect of the CLM construct validity assessment. Aspects of the overview of CLM obtained an average score of 3.9 which is included in the very valid category, and a reliability coefficient of 96% is included in the reliable category. The conformity aspect of CLM with theoretical and empirical support obtained an average score of 3.9 which is included in the very valid category, and a reliability coefficient of 97% is included in the reliable category. Aspects of planning and implementation of CLM obtained an average score of 3.8 which is included in the very valid category, and a reliability coefficient of 100% is included in the reliable category. Aspects of the learning environment of CLM obtained an average score of 3.8 which is included in the very valid category, and a reliability coefficient of 93% is included in the reliable category. Likewise, in the aspect of assessment and evaluation, an average score of 4 is obtained which is included in the very valid category, and a reliability coefficient of 100% is included in the reliable category. Based on the results of the content validity assessment, it can be concluded that the five aspects are included in the very valid and reliable category.

ResultsExpert assessment shows that CLM is included in the very valid category both in terms of content and constructs. Substantially, the concepts developed in the CLM have met the elements of the model development criteria, and have fulfilled all the model components. However, based on the results of the FGD technically such as writing, the CLM description method needs improvement as shown in Table 4.5.

Table 4.5 CLM Suggestions and Improvements based on FGD

Material validity	Suggestion	Repair
CLM	LMS is used as a learning media only, do not use it in the learning process because it will narrow learning activities as a basis for considering areas where internet access is difficult.	LMS is used before learning as a material to send material, and after learning in the form of a mind mapping chart, a summary of the material.
	Phase -2 investigations should focus on efforts to achieve learning objectives, and group activities on strategies to facilitate learning outcomes.	It has been fixed that the main focus in Phase-2 of the investigation is the achievement of learning objectives.
	Describe each figure or Table in the CLM academic paper	An explanation of each table or figure in the CLM academic manuscript is given.

2. Validity of CLM Supporting Learning Tools

ImplementationCLM will not be optimal without the support of learning tools. CLM supporting tools include Semester Learning Plans (RPS) and SAP, Student Textbooks (BAM). The FGD activities also carried out validation of learning tools, and the KBK-KL Test instrument.

a. Validity of Semester Learning Plans (RPS) and Learning Program Units (SAP)

RPS, and SAP are developed using the CLM syntax which consists of five phases. The five phases include learning orientation, inquiry, reasoning, clarification and evaluation, and reflection. RPS validity includes content and construct validity which are described as follows

The measurement of the validity of the content of the RPS and SAP uses a validity sheet consisting of 6 statements covering three aspects of the assessment. These three aspects include completeness of identity as much as 1 statement, formulation of the final planned ability as much as 2 statements, and components of study materials, learning experiences and learning resources as many as 3 statements. The results of the assessment of the validity of the content of the RPS are shown in Table 4.6. Details of the results of the validity of the contents of the RPS and SAP can be seen in Appendix A. 1.03.

Table 4.6 RPS Content Validity Assessment Results, and SAP

No	Validation item	$\underline{V}$	Note :	Reliability	
				R	Note:
1.	Identity equipment	3.7	SV	89%	Reliable
2.	Formulation of planned final capabilities	3.7	SV	86%	Reliable
3.	Study materials, learning experiences and learning resources	3.8	SV	96%	Reliable

Description: = average score of the three validators, R = coefficient of reliability.$\underline{V}$

Based on Table 4.6, the results of the validity and reliability of each aspect of the assessment of the validity of the content of the RPS are obtained. Aspects of completeness of identity obtained an average score of 3.7 which is included in the very valid category, and a reliability coefficient of 89% is included in the reliable category. Aspects of the final planned ability formulation obtained an average score of 3.7 which is included in the very valid category, and a reliability coefficient of 86% is included in the reliable category. Likewise, in the aspect of learning experiences and learning resources, an average score of 3.8 is obtained which is included in the very valid category, and a reliability coefficient of 96% is included in the reliable category. Based on the results of the assessment of the validity of the content of the RPS, it can be concluded that the three aspects are included in the very valid and reliable category.

As with content validity, the measurement of the construct validity of the RPS and SAP used a validity sheet consisting of 6 statements with three aspects of assessment. The three aspects include the presentation in learning of 2 statements, time allocation of 2 statements, and assessment of 2 statements. The results of the assessment of the validity of the RPS and SAP constructs are shown in Table 4.7. Details of the results of the RPS and SAP construct validity can be seen in Appendix A. 1.04.

Table 4.7 RPS and SAP construct validity assessment results

No	Validation item	$\underline{V}$	Note:	Reliability	
				R	**Note:**
1.	Presentation in learning	4	SV	100%	Reliable
2.	Time Allocation	3.7	SV	97%	Reliable
3.	Assessment	3.8	SV	100%	Reliable

Description: = average score of the three validators, R = coefficient of reliability. $\underline{V}$

Based on Table 4.7, the results of the validity and reliability of each aspect of the assessment of the validity of the RPS and SAP constructs are obtained. Aspects of presentation in learning obtained an average score of 4 which is included in the very valid category, and a reliability coefficient of 100% is included in the reliable category. Aspects of time allocation with theoretical and empirical support obtained an average score of 3.7 which is included in the very valid category, and a reliability coefficient of 97% is included in the reliable category. Aspects of planning and implementation of CLM obtained an average score of 3.8 which is included in the very valid category, and a reliability coefficient of 100% is included in the reliable category. Aspects of the assessment obtained an average score of 3.8 which is included in the very valid category, and a reliability coefficient of 100% is included in the reliable category.

Results Expert assessment shows that RPS and SAP are included in the very valid category both in terms of content and constructs. Substantially, the concepts developed in the RPS and SAP have met the elements of the RPS and SAP development criteria. However, based on the results of the FGD, technically the RPS and SAP there are suggestions from experts that need improvement as shown in Table 4.8.

Table 4.8 RPS and SAP Suggestions and Improvements based on FGD

Material validity	Suggestion	Repair
RPS and SAP	Make sure the bibliography is up-to-date	New reference has been added a. Knight, Randall D. 2013. Physics For Scientists and Engineers A Strategic Approach With Modern Physics. Boston: Pearson. b. Knights. Randall D 2017. Physics for Scientists and Engineers: A Strategic Approach with Modern Physics. Fourth Edition. Boston: Pearson c. Kristanto, Philip. 2019. Basic Physics, Theory. Problems, and Solutions. Surabaya: Andi
	Check the time allocation again	The time allocation for phase-1 was reduced by 5 minutes, for phase -2 the investigation was added 5 minutes.

b. Student Textbook Validity (BAM)

BAM was developed based on the research objectives, namely being able to train critical thinking skills, advanced clarification and the content of the material was developed based on the RPS. BAM validity includes content and construct validity which are described as follows.

Measurement of the validity of the content of the BAM using a validity sheet consisting of 7 statements covering three aspects of the assessment. These three aspects include the suitability of the material with learning outcomes as many as 3 statements, the accuracy of the material as much as 2 statements, and supporting learning as many as 2 statements. The results of the BAM content validity assessment are shown in Table 4.9. The details of the validity of the contents of the BAM are as safe as Appendix A. 1.05.

Table 4.9 BAM Content Validity Assessment Results

No	Validation item	$\underline{V}$	Note :	Reliability	
				R	Note:
1.	The suitability of the material with learning outcomes	4	SV	100%	Reliable
2.	Material accuracy	3.6	SV	86%	Reliable
3.	Learning support	4	SV	100%	Reliable

Description: = the average score of the three validators, R = the reliability coefficient.$\underline{V}$

Based on Table 4.9, the results of the validity and reliability of each aspect of the BAM content validity assessment are obtained. Aspects of the suitability of the material obtained an average score of 4 which is included in the very valid category, and a reliability coefficient of 100% is included in the reliable category. Aspects of the accuracy of the planned material obtained an average score of 3.6 which is included in the very valid category, and a reliability coefficient of 86% is included in the reliable category. Likewise, in the aspect of supporting learning, an average score of 4 is obtained which is included in the very valid category, and a reliability coefficient of 100% is included in the reliable category. Based on the results of the

BAM content validity assessment, it can be concluded that the three aspects are included in the very valid and reliable category.

As with content validity, the measurement of construct validity of BAM uses a validity sheet consisting of 14 statements covering three aspects of the assessment. The three aspects include the presentation technique of 4 statements, the presentation of the material as many as 5 statements, and the completeness of the presentation of 5 statements. The results of the BAM construct validity assessment are shown in Table 4.10. Details of the BAM construct validity details are shown in Appendix 1. A. 1.06.

Table 4.10 BAM construct validity assessment results

No	Validation item	$\underline{V}$	Note :	Reliability	
				R	Note:
1.	Presentation technique	4	SV	100%	Reliable
2.	Material presentation	3.9	SV	97%	Reliable
3.	Serving equipment	3.6	SV	97%	Reliable

Description: = average score of the three validators, R = coefficient of reliability. $\underline{V}$

Based on Table 4.10, the results of the validity and reliability of each aspect of the BAM construct validity assessment are obtained. Aspects of the presentation technique obtained an average score of 4 which is included in the very valid category, and a reliability coefficient of 100% is included in the reliable category. Aspects of material presentation with theoretical and empirical support obtained an average score of 3.9 which is included in the very valid category, and a reliability coefficient of 97% is included in the reliable category. The aspect of completeness of presentation obtained an average score of 3.6 which is included in the very valid category, and a reliability coefficient of 97%% is included in the reliable category. Based on the results of the BAM construct validity assessment, it can be concluded that the three aspects are included in the very valid and reliable category.

Results Expert assessment shows that BAM is included in the very valid category both in content and constructs. Substantially, the concepts developed in BAM have fulfilled the elements of textbook development. However, based on the results of the FGD, technically, BAM has suggestions from experts that need improvement as shown in Table 4.11.

Table 4.11 BAM Suggestions and Improvements based on FGD

Material validity	Suggestion	Repair
BAM	We recommend that you use a new library so you don't seem to use expired materials, if necessary, support the latest research results in the 2018-2021 range.	New reference has been added a. Knight, Randall D. 2013. Physics For Scientists and Engineers A Strategic Approach With Modern Physics. Boston: Pearson. b. Knight, Randall D. 2017. Physics for Scientists and Engineers: A Strategic Approach with Modern Physics. Fourth Edition. Boston: Pearson c. Kristanto, Philip. 2019. Basic Physics, Theory. Problems, and Solutions. Surabaya: Andi

C. CLM practicality

The practicality of CLM is obtained through the results of a limited-scale and wide-scale test. The implementation of the limited-scale test begins in September the fourth week to October the third week of 2021. The subject of the research is testing the Prototype 2 CLM at Trunojoyo University, Madura. Students who received intervention using CLM consisted of two classes, namely PIF B class, which consisted of 24 students, and PIF D class, which consisted of 18 students. The purpose of implementing a limited-scale test is to determine the practicality, effectiveness of improving critical thinking ability on advanced clarification, as well as evaluating CLM to obtain prototype 3.

Preparations made to obtain optimal results were carried out by coordinating with two observers and socializing and simulating the CLM PIF B and PIF D models. Coordination with observers was conveying technical assignments, providing learning implementation observation sheet instruments, and learning constraints sheet instruments. Coordination with students, namely delivering CLM and simulations of using Phet Simulation media to carry out the investigation process.

CLM implemented for 8 times face to face with details 4 times in PIFB class, and 4 times in PIF D Informatics Education Study Program. The results of observations on the implementation of CLM in PIF class B are presented in Table 4.12. Details of the implementation of CLM in class B are shown in Appendix A. 2.01.01.

Table 4.12 The results of the implementation of the CLM Limited Scale PIF Class B test.

No	Phase	Meeting 1			Meeting 2			Meeting 3			Meeting 4		
		P	Note:	R	P	Note:	R	P	Note:	R	P	Note:	R
1	Learning Orientation	3.5	SB		3.8	SB		3.9	SB		4	SB	
2	Investigation	3.5	SB		3.5	SB		3.5	SB		3.5	SB	
3	Reasoning	4	SB	96%	4	SB	98%	4	SB	98%	4	SB	100 %
4	Clarification and evaluation	4	SB		4	SB		4	SB		4	SB	
5	Reflection	3.7	SB		3.8	SB		3.8	SB		4	SB	
Average of all phases		3.74	SB		3.82	SB		3.84	SB		3.9	SB	

Information: P= observer-average, SB= very good.

Based onTable 4.12 the average of all phases at meeting 1 obtained a score of 3.74 which is included in the very good category, and 96% reliability is included in the reliable category. The average score of all phases of meeting 2 is 3.82 which is included in the very good category, and 98% reliability is included in the reliable category. The average score of all phases of meeting 3 is 3.84 which is included in the very good category, and 98% reliability is included in the reliable category. The average score of all phase 4 meetings of 3.9 is included in the very good category, and 100% reliability is included in the reliable category. Thus, all CLM meetings are included in the very good and reliable category.

ImplementationCLM in the second class is PIF D Informatics Education Study Program. The implementation of CLM for 4 face-to-face meetings starting from September to October 2021. The results of implementation in this class are presented in Table 4.13, detailed details can be seen in the AppendixA. 2.01.02.

Table 4.13 Results The results of the CLM implementation of the Limited Scale PIF Class D test.

No	Phase	Meeting											
		1			2			3			4		
		$\underline{P}$	Note:	R	$\underline{P}$	Note:	R	$\underline{P}$	Note:		$\underline{P}$	Note:	R
1	Learning Orientation	**3.5**	SB		**3.9**	SB		**3.9**	SB		**4**	SB	
2	Investigation	3.5	SB		3.5	SB		3.5	SB		3.5	SB	
3	Reasoning	4	SB	**97%**	4	SB	**98%**	4	SB	**97%**	4	SB	97%
4	Clarification and evaluation	4	SB		4	SB		4	SB		4	SB	
5	Reflection	3.7	SB		3.8	SB		3.8	SB		4	SB	
Average of all phases		3.74	SB		3.84	SB		3.84	SB		3.9	SB	

Information:$\underline{P}$= observer average, SB= very good.

Based onTable 4.13 the average of all phases at meeting 1 obtained a score of 3.74 which is included in the very good category, and 97% reliability is included in the reliable category. The average score of all phases of meeting 2 of 3.84 is included in the very good category, and 98% reliability is included in the reliable category. The average score of all phases of meeting 3 of 3.84 is included in the very good category, and 97% reliability is included in the reliable category. The average score of all phases of meeting 4 of 3.9 is included in the very good category, and 97% reliability is included in the reliable category. Thus, all CLM meetings are included in the very good and reliable category.

Implementation Learning during four meetings at the time of the limited scale test made some improvements. The results of the evaluation of the implementation of learning can be concluded that each phase of CLM is practical to use. This result is inseparable from the evaluation of each meeting for optimization of CLM syntax. The evaluation of the application of CLM in a limited test is presented in Table 4.14.

Table 4.14 Evaluation of CLM Implementation in Limited Test

Meeting	Constraint	Recommendations for improving the quality of learning
First	**SAP Scenario** 1. Regarding the suitability of time, it needs attention because in the introduction it takes quite a long time. 2. Network connection problems are still a problem, so students cannot display the video. 3. The group discussion process did not run smoothly 4. Students are not ready to attend lectures.	1. The need for affirmation so that students are more interactive when there are questions and answers between lecturers and students. 2. The need for time changes in the developed model, especially the learning orientation section.
Second	**SAP Scenario** 1. Network connection problems are still a problem, so students cannot display the video. 2. There are students who are difficult to enter via Zoom meeting. 3. Students are afraid of confirmation of understanding. 4. Students lack time to complete investigations and reasoning tasks	1. The need for periodic checks regarding student attendance on a regular basis. 2. It is necessary to make a practical simulation tutorial using Phet Simulation and send it via LMS before meeting. 3. Reasoning tasks need to be shared before face-to-face.
Third	1. Network connection problems are still a problem, so students can't display the video Textbooks	1. Fixed reasoning task maintained as a pre-school assignment. 2. Optimization Question and answer 3. Confirmation of material for each meeting Textbooks

Meeting	Constraint	Recommendations for improving the quality of learning
	There are errors in making conclusions in the discussion of the reasoning task. There are spelling errors like arrow, in appeal and the use of spaces.	Improvement of making conclusions on the reasoning task. Spelling and spacing improvements.
Fourth	1. Network connection problems are still a problem, so students can't display the video 2. Students are afraid of confirmation of understanding.	1. The provision of simulation videos is still maintained as an investigation exercise. 2. Fixed reasoning task maintained as a pre-school assignment. 3. Optimization Question and answer 4. Confirmation of material for each meeting.

Based onTable 4.14 shows the evaluation of each effective meeting for CLM optimization. Problems encountered at one meeting were not repeated in the next meeting, except for network problems. Implementation of CLM evaluation of each meeting has a positive impact on the next meeting. The suggestion from the fourth meeting is the basis for improvement to produce 3 CLM prototypes. In addition to learning, there are also BAM weaknesses, especially in spelling and writing, especially on the topics discussed at the third meeting, namely effort and energy.

Suggestions at the fourth meeting were to consult with the Promoter and Co-promoter and pay attention to the success of the KBK-KL achievement in obtaining Prototype 3 CLM. The contents of the suggestions given by the supervisor are as shown in Table 4.15.

Table 4.15 Evaluation of Prototype 2 CLM based on Limited Scale Test

No	Suggestion	Information
1.	LMS optimization for pre-learning	In addition to giving textbooks, students need to be given practical simulation videos using Phet Simulation, and reasoning tasks so that students can practice before the virtual face-to-face takes place.
2.	Continue to confirm understanding to students.	Lecturers need to open up and often ask how they understand the explanations that have been made by the lecturer.
3.	Material reinforcement	For material that is important, the lecturer needs to confirm the material through words that are repeated twice or convey that this is the key word of the material.
4.	Spelling and grammar improvements	The finding of spelling and writing errors during the learning process needs to be corrected immediately.

Based onTable 4.15 suggestions given by promoters and co-promoters without changing the validity of the previous CLM and CLM kits. This recommendation is a form of improving the quality of learning and improving grammar and spelling only. The prototype 3 CLM was tested extensively in three universities, namely Trunojoyo Madura University, Lampung University and Ivet University Semarang. Two classes that received CLM intervention at Trunojoyo University Madura in the Informatics Education Study Program were 27 students PIF A and 26 students PIF C. For the University of Lampung, it was carried out in the Information Technology Education Study Program in one class with a total of 25 students. While at Ivet University Semarang in the Informatics Education Study Program with a total of 29 students.

PreparationWhat is done to obtain optimal results is done through training of model lecturers, coordinating with two observers, as well as socializing and simulating the CLM model with students. Model lecturer training conveys the objectives and technical syntax in CLM which consists of five phases. The model training is quite effective because the model lecturer who conducts the learning is the observer of the research at the time of the limited-scale test. Coordination with observers is conveying technical assignments, providing learning implementation observation sheet instruments, and learning constraints sheet instruments. Coordination with students, namely delivering CLM and simulations of using Phet Simulation media to carry out the investigation process.

CLM implemented for 16 face-to-face meetings with details of 4 times at PIFA UTM, and 4 times at PIF D UTM, 4 times at PTI UNILA, and 4 times at PIF IVET Semarang. The results of observations on the implementation of CLM are presented in Table 4.16. The details can be seen in Appendix A. 2.02.01, Appendix A. 2.02.02, Appendix A. 2.02.03, Appendix A. 2.02.04.

Table 4.16. Results of CLM Observations in the Large-Scale Trial.

Meeting	**Phase**	**Trunojoyo University Madura**				**Lampung University**		**Ivet University Semarang**	
		PIF A		**PIF C**		**PTI UNILA**		**PIFIVET**	
		<u>P</u>	**Kat**	<u>P</u>	**Kat.**	<u>P</u>	**Kat**	<u>P</u>	**Kat**
1	1	3.9	Very good	3.9	Very good	3.9	Very good	3.9	Very good
	2	3.5	Very good	3.5	Very good	3.5	Very good	3.5	Very good

Meeting	Phase	Trunojoyo University Madura				Lampung University		Ivet University Semarang	
		PIF A		PIF C		PTI UNILA		PIFIVET	
		P	Kat	P	Kat.	P	Kat	P	Kat
	3	4	Very good	4	Very good	4	Very good	4	Very good
	4	4	Very good	4	Very good	4	Very good	4	Very good
	5	3.7	Very good	3.7	Very good	3.7	Very good	3.7	Very good
2	1	4	Very good	4	Very good	4	Very good	4	Very good
	2	3.5	Very good	3.5	Very good	3.5	Very good	3.5	Very good
	3	4	Very good	4	Very good	4	Very good	4	Very good
	4	4	Very good	4	Very good	4	Very good	4	Very good
	5	3.8	Very good	3.8	Very good	3.8	Very good	3.8	Very good
3	1	4	Very good	4	Very good	4	Very good	4	Very good
	2	3.5	Very good	3.5	Very good	3.5	Very good	3.5	Very good
	3	4	Very good	4	Very good	4	Very good	4	Very good
	4	4	Very good	4	Very good	4	Very good	4	Very good
	5	3.8	Very good	3.8	Very good	3.8	Very good	3.8	Very good
4	1	4	Very good	4	Very good	4	Very good	4	Very good
	2	3.5	Very good	3.5	Very good	3.5	Very good	3.5	Very good
	3	4	Very good	4	Very good	4	Very good	4	Very good

Meeting	Phase	Trunojoyo University Madura				Lampung University		Ivet University Semarang	
		PIF A		PIF C		PTI UNILA		PIFIVET	
		P	Kat	P	Kat.	P	Kat	P	Kat
	4	4	Very good	4	Very good	4	Very good	4	Very good
	5	4	Very good	4	Very good	4	Very good	4	Very good
Reliability		99%	reliable	99%	Reliable	99%	Reliable	100%	Reliable

Description: Phase 1= Learning Orientation, Phase 2= Investigation, Phase 3= Reasoning, Phase 4= clarification and evaluation, , = Observer's mean score.P

Based on Table 4.16 the average of all phases at meeting one to meeting four is included in the very good category. And the level of reliability is more than 75% or included in the reliable category. Thus, all CLM meetings are included in the very good and reliable category. Evaluation of the application of CLM in a wide-scale test is presented in Table 4.17.

Table 4.17. Evaluation of CLM Application in Broad-Scale Test

Meeting	Constraint	Recommendations for improving the quality of learning
First	1. Part Students experiencing network connection problems 2. In the introduction exceeded the predetermined target. 3. Students are not familiar with making explanatory arguments based on concepts.	1. Need to be more disciplined in timing each phase. 2. Need the help of keywords to make an argument.
Second	1. Network connection problems are still a problem, so students cannot display the video. 2. Students have not fully dared to submit the results of independent assignments and quizzes.	1. Strengthening student motivation to dare to appear conveying the results of work assignments. 2. It is necessary to strengthen assistance in making arguments in order to increase the courage of students to dare to convey the

Meeting	Constraint	Recommendations for improving the quality of learning
		results of working on questions.
Third	1. Network connection problems are still a problem, so students cannot display the video. 2. Some students are still passive in participating in learning.	Giving appreciation to students who actively convey the results of their work
Fourth	1. Network connection problems are still a problem, so students can't display the video 2. Some students who have small RAM need longer time in the simulation process using Phet Simulation.	Strengthening TEAM cooperation on the strategy of using high-spec laptops in the investigation process to streamline time

Based on Table 4.17, the findings of weaknesses in the implementation of CLM are found. Implementation of CLM evaluation of each meeting has a positive impact on the next meeting. Three things are important to improve the quality of CLM, namely mentoring by making keywords in arguments, giving appreciation for students who dare to appear, and setting strategies for using high-spec laptops as a simulation medium for important things to improve CLM. These suggestions will be used as the basis for the formation of the final CLM prototype.

D. CLM Effectiveness

Testing the effectiveness of CLM was carried out twice, namely the limited-scale test and the broad-scale test. The effectiveness of CLM was measured using the KBK-KL test instrument and student response questionnaires. Both measurements using the KBK-KL test instrument and student response questionnaires are described as follows.

1. KBK-KL students

The effectiveness of CLM and validated learning support tools to improve expert KBK-KL was measured using a test measuring instrument. As stated in the previous chapter, the test of the impact of CLM learning and the learning tools of this product was carried out on Vocational Education and Information Technology students which included Informatics Education and Information Technology Education in the Basic Physics course. The subjects of this study were given a pretest before participating in the developed CLM, and took a post-test after each lesson. This activity was carried out on both a limited scale test and a wide scale test. According to the research objectives, the increase in KBK-KL will be measured on all indicators and each indicator will be analyzed

a. KBK-KL Score on All Indicators Review

The increase in KBK-KL on all indicators will be analyzed by N-Gain, and the achievement of the category of critical thinking skills. CLM is effective in increasing the KBK-KL if the average minimum score is in the moderate category (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006). Meanwhile, on average, the achievement of the KBK-KL indicators for students, at least students are included in the fairly critical category (Pursitasari *et al*., 2020). The overall N-Gain score of the KBK-KL indicators is shown in Table 4.18. Details of the limited-scale trial KBK-KL can be seen in Appendix A. 3.01.01 and Appendix A. 3.01.01. Meanwhile, large-scale trials can be seen in Appendix A. 3.02.01, Appendix A. 3.02.02, Appendix A. 3.02.03, and Appendix A. 3.02.04.

Table 4.18. Summary of N-Gain Average KBK-KL Limited-Scale Test and Broad-Scale Test

KBK-KL Uji Test	Class	Variable	Average	*N-Gain*	Category
Limited Scale	PIF B UTM	*Pre-test*	3.29	0.68	Midle
		Post-test	27.88		
	PIF D UTM	*Pre-test*	3.11	0.67	Midle

		Post-test	27.17		
	Average			0.68	Midle
Wide Scale	PIF A UTM	*Pre-test*	3.67	0.80	High
		Post-test	32.07		
	PIF C UTM	*Pre-test*	3.04	0.81	High
		Post-test	32.42		
	PTI UNILA	*Pre-test*	2.68	0.82	High
		Post-test	32.76		
	PIF IVET Semarang	*Pre-test*	3.83	0.82	High
		Post-test	33		
	Average			0.81	High

Based on Table 4.18 above, the N-Gain score on the limited test scale for the PIF B UTM class of 0.68 is included in the medium category, the PIF D UTM class of 0.67 is included in the medium category, and the average of the two classes is 0.68 included in the medium category. The N-Gain score on the PIF A UTM broad scale test of 0.80 is included in the high category, the PIF C UTM class of 0.81 is included in the high category, the PTI UNILA class of 0.82 is included in the high category, the PIF IVET class of 0.82 is included in the high category and the average of the four classes is 0.81 which is included in the high category. Thus, there is an increase in the N-Gain of KBK-KL on a wide-scale test. The following is a presentation of the increase in KBK-KL during the small-scale test and the wide-scale test as shown in the graph in Figure 4.3.

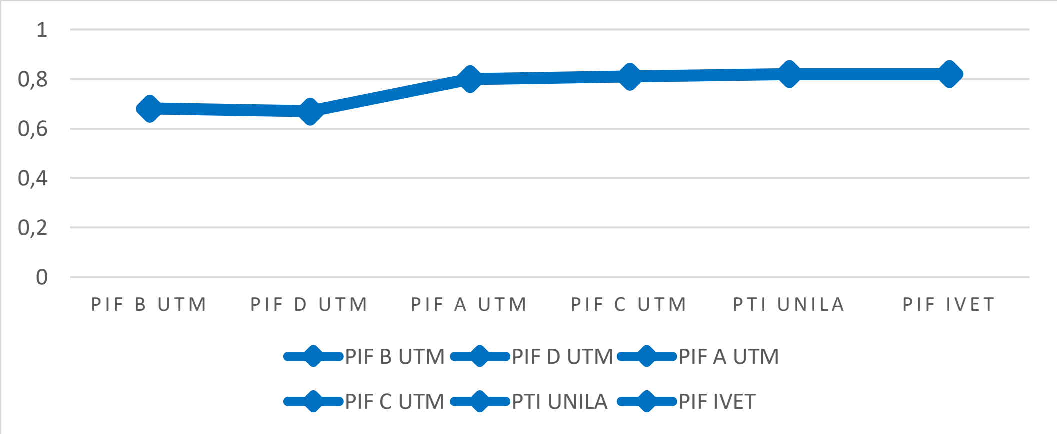

Figure 4.3 Graph of Mean N-Gain on Limited-Scale Test and Broad-Scale Test

Based on Figure 4.3, it should be noted that the limited-scale test was carried out in the PIF B UTM and PIF D UTM classes, while the broad-scale test was in the PIF A UTM, PIF C UTM, PTI UNILA, and PIF IVET classes. The graph of the KBK-KL N-Gain score shows that there is an increase in the wide-scale test. This means that the N-Gain score of the KBK-KL broad-scale test is higher than the limited-scale test. The distribution of N-Gain data is shown in Histogram Figure 4.4.

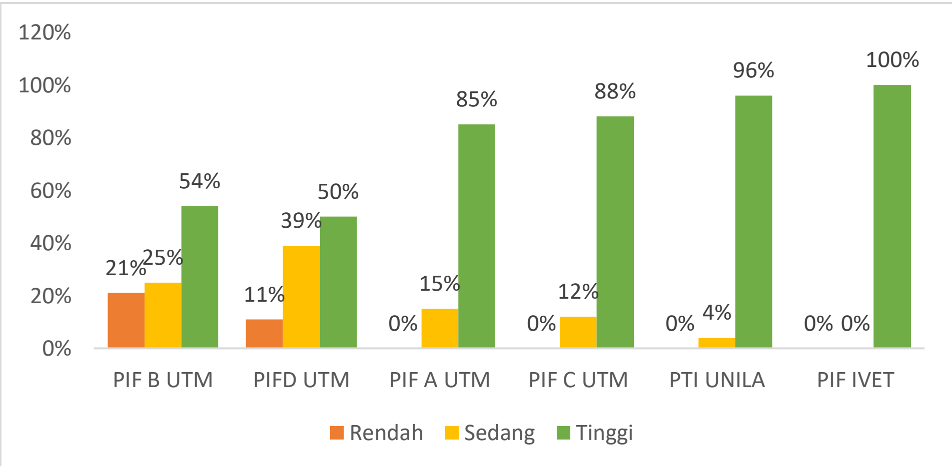

Figure 4.4 Distribution of N-Gain on Limited-Scale Test and Broad-Scale Test

Based on Figure 4.4, both in the limited-scale test and the wide-scale test of the N-Gain distribution, the majority of the distribution is in the high category. Especially for the broad-scale test, there were no students who experienced an increase in N-Gain at a low level, even the achievement of N-Gain was between the range of 85%-100%. Thus, the increase in the influence of CLM learning and its equipment, the majority of students in one class experienced an increase in the high category.

In addition to looking for an increase in N-Gain, the processing of the KBK-KL score can also be analyzed at the level of the critical thinking ability category. Category levels from low to high are very less critical, less critical, moderately critical, critical, and very critical (Pursitasari *et al*., 2020). The level of the KBK-KL category is as shown in Table 4.19 which is the processing in Appendix A. 3.01.01 and Appendix A. 3.01.01. Meanwhile, large-scale trials can be seen in Appendix A. 3.02.01, Appendix A. 3.02.02, Appendix A. 3.02.03, and Appendix A. 3.02.04.

Table 4.19 Student's Critical Thinking Ability Level on Limited Scale Test and Wide Scale Test

KBK-KL Uji Test	**Class**	***Pre-test***		***Post-test***	
		Score	**Category**	**Score**	**Category**
Limited Scale	PIF B UTM	*3.29*	Very Less Critical	27.88	Critical Enough
	PIF D UTM	3.11	Very Less Critical	27.17	Critical Enough

KBK-KL Uji Test	Class	*Pre-test*		*Post-test*	
		Score	**Category**	**Score**	**Category**
	Average	3.21	Very Less Critical	27.57	Critical Enough
Wide Scale	PIF A UTM	3.67	Very Less Critical	32.07	Critical
	PIF C UTM	3.04	Very Less Critical	32.42	Critical
	PTI UNILA	2.68	Very Less Critical	32.76	Critical
	PIF IVET Semarang	3.83	Very Less Critical	33	Critical
	Average	3.32	Very Less Critical	32.56	Critical

Based on Table 4.19, both the limited-scale test and the wide-scale test the distribution of students' critical thinking ability levels have reached the minimum target, which is quite critical (Pursitasari *et al.*, 2020). The results of the limited scale test show that the PIF B UTM class with an average score of 27.88 is included in the moderately critical category, PIF D UTM with an average score of 27.17 is included in the moderately critical category, and the average of the two classes with a score of 27.57 is included in the moderately critical category. The results of the broad-scale test show that PIF A UTM class with a mean score of 32.07 is included in the critical category, PIF C UTM with an average score of 32.76 is included in the critical category, PTI UNILA with a mean score of 32.76 is included in the critical category, PIF IVET with the average score of 33 is included in the critical category and the average of the four classes with a score of 32.56 is included in the critical category.

b. Each KBK-KL Indicator

Each KBK-KL indicator will be analyzed by N-Gain, and the achievement of the critical thinking ability category. CLM is effective in increasing the KBK-KL if the minimum average score is in the moderate category (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006). Meanwhile, the average student achievement of the KBK-KL indicator is at least the students included in the fairly critical category (Pursitasari *et al*., 2020). The N-Gain score for each KBK-KL indicator is shown in Table 4.20.

Table 4.20.N-Gain Category on Each KBK-KL Indicator Limited-Scale Test and Broad-Scale Test

KBK-KL Indikator Indicators	Scale Test	Class	*N-Gain*	Category
Assess phenomena based on appropriate concepts	Limited	PIF B UTM	0.93	High
		PIF D UTM	0.93	High
		Average	0.93	High
	Large	PIF A UTM	0.98	High
		PIF C UTM	0.97	High
		PTI UNILA	0.97	High
		IVET PIF	0.97	High
		Average	0.97	High
Evaluating a person's line of thought	Limited	PIF B UTM	0.64	Midle
		PIF D UTM	0.63	Midle
		Average	0.64	Midle
	Large	PIF A UTM	0.73	High

KBK-KL Indikator Indicators	Scale Test	Class	*N-Gain*	Category
		PIF C UTM	0.74	High
		PTI UNILA	0.86	High
		IVET PIF	0.98	High
		Average	0.82	High
Identify unstated assumptions	Limited	PIF B UTM	0.65	Midle
		PIF D UTM	0.65	Midle
		Average	0.65	Midle
	Large	PIF A UTM	0.75	High
		PIF C UTM	0.77	High
		PTI UNILA	0.78	High
		IVET PIF	0.77	High
		Average	0.76	High
Predictive thinking	Limited	PIF B UTM	0.61	Midle
		PIF D UTM	0.62	Midle
		Average	0.62	Midle
	Large	PIF A UTM	0.75	High
		PIF C UTM	0.76	High
		PTI UNILA	0.79	High
		IVET PIF	0.80	High
		Average	0.77	High
Handling label errors	Limited	PIF B UTM	0.83	High
		PIF D UTM	0.76	High
		Average	0.80	High
	Large	PIF A UTM	0.91	High
		PIF C UTM	0.93	High
		PTI UNILA	0.95	High
		IVET PIF	0.93	High
		Average	0.93	High
Metacognitive thinking	Limited	PIF B UTM	0.59	Midle

KBK-KL Indikator Indicators	Scale Test	Class	*N-Gain*	Category
		PIF D UTM	0.58	Midle
		Average	0.59	Midle
	Large	PIF A UTM	0.74	High
		PIF C UTM	0.77	High
		PTI UNILA	0.74	High
		IVET PIF	0.73	High
		Average	0.74	High
Solving problems in order	Limited	PIF B UTM	0.65	Midle
		PIF D UTM	0.60	Midle
		Average	0.63	Midle
	Large	PIF A UTM	0.80	High
		PIF C UTM	0.80	High
		PTI UNILA	0.75	High
		IVET PIF	0.72	High
		Average	0.76	High

Based on Table 4.20, the data shows that in both the limited scale test and the wide scale test, the minimum N-Gain score is in the medium category and the maximum is in the high category. The results of the limited-scale test of two KBK-KL indicators are included in the high category, namely assessing phenomena with the right concept and handling label errors. While the other five indicators are included in the moderate category, namely evaluating a person's line of thought, identifying unstated assumptions, predictive thinking, metacognitive thinking, and solving problems sequentially. The results of the wide-scale test of all KBK-KL indicators are included in the high category with detailed indicators assessing phenomena with the right concept and handling error labels evaluating a person's line of thought, identifying unstated assumptions, predictive thinking, metacognitive thinking, and solving problems sequentially. The average difference in the increase in N-Gain for the limited scale test and the wide scale of each indicator is shown in Figure 4.5.

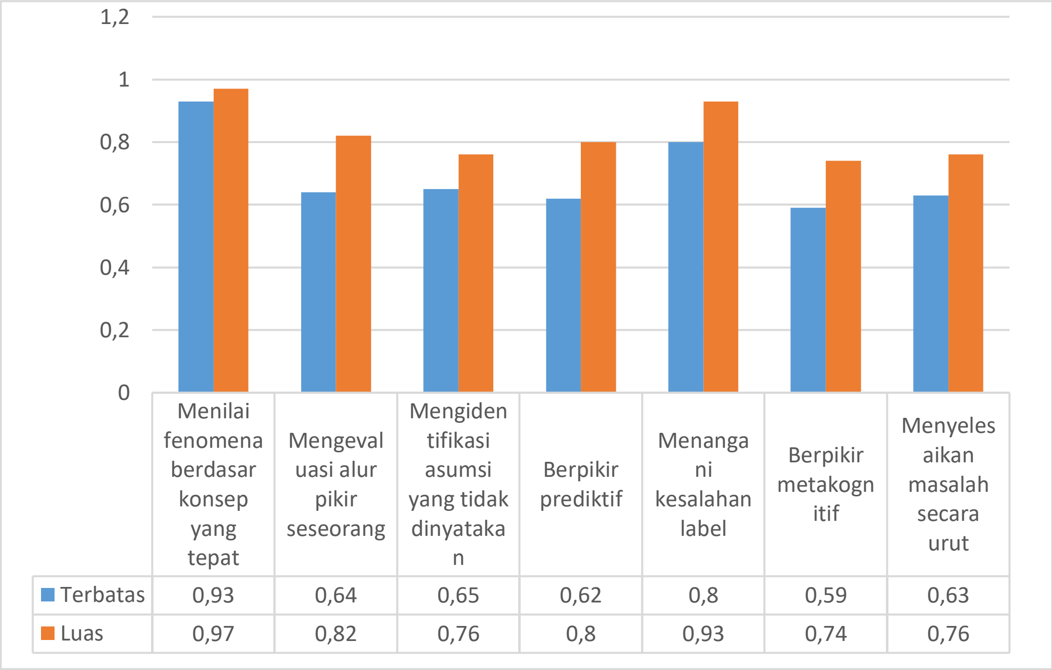

Figure 4.5 Differences in N-Gain Improvement in Limited Scale and Extensive Tests of Each KBK-KL Indicator

Based on Figure 4.5 the average results of the N-Gain of each KBK-KL indicator in the broad-scale test are higher than the limited-scale test. The results of the wide-scale test of the highest increase in N-Gain with a mean score of 0.97 on indicators assessing phenomena based on the right concept. While the lowest rank with an average N-Gain 0.74 on the indicator of metacognitive thinking.

In addition to looking for an increase in N-Gain, the processing of each KBK-KL score indicator can also be analyzed at the level of the critical thinking ability category. Category levels from low to high are very less critical, less critical, moderately critical, critical, and very critical (Pursitasari *et al*., 2020). Based on Table 4.20, the pre-test and post-test score data can be measured at the level of the KBK-KL category as shown in Figure 4.6 and Figure 4.7.

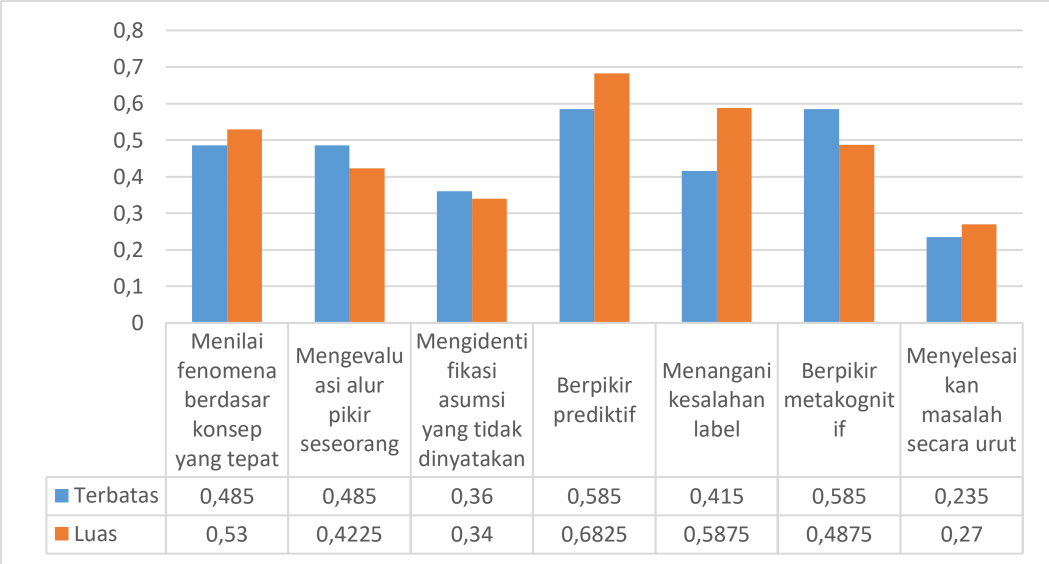

Figure 4.6 Mean Pre-test Scores of Limited Scale and Broad Scale Trials on Each KBK-KL Indicator

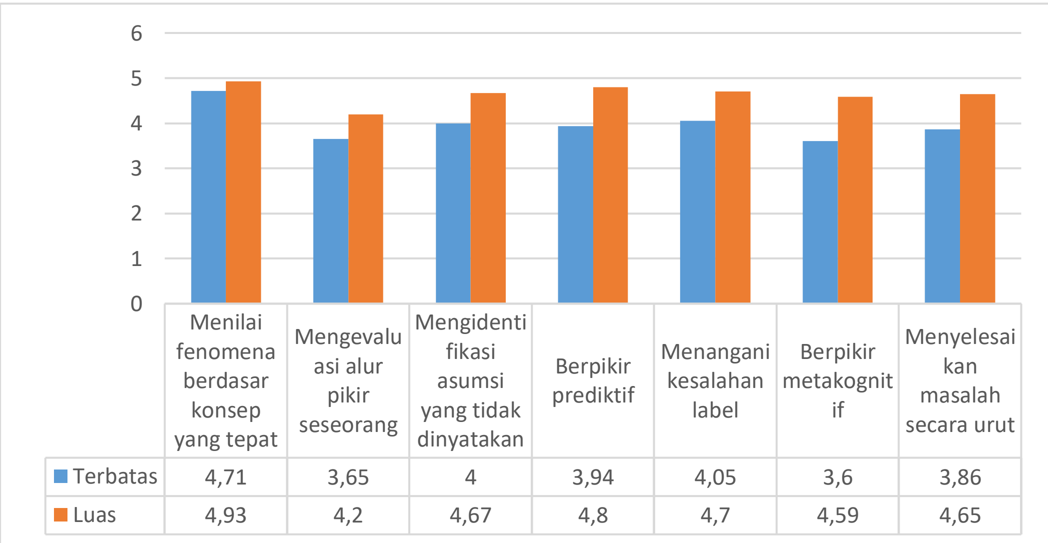

Figure 4.7 Mean Post-test Scores of Limited Scale and Broad Scale Trials on Each KBK-KL Indicator

Based on Figure 4.6 and Figure 4.7, there is information on pre-test scores and post-test scores for each KBK-KL indicator, so it can be determined the level of critical thinking skills starting from very less critical, less critical, quite critical, critical, and very critical (Pursitasari *et al*., 2020). The presentation of each indicator is as follows. The first indicator KBK-KL assesses the phenomenon based on the right concept. Based on the scoring guide on this indicator, the lowest score is 0 and the maximum is 5. Based on Figure 4.6 the pre-test score range on the small-scale test is 0.48, the large-scale test is 0.53 then both are included in the very less critical category. While in Figure 4.7 the post-test scores on the PIF B UTM and PIF D UTM limited scale tests are 4.70 included in the very critical category and 4.72 included in the very critical category. The average result of the two classes is 4.71, so that the limited scale test is included in the very critical category. The results of the wide-scale test experienced an increase in PIF A UTM scores by 5, PIF C UTM by 5, PTI UNILA 4.84, and PIF IVET 4.90 the four classes were included in the very critical category. The average result of the four classes is 4.93, so that the broad-scale test is included in the very critical category

The second indicator of the KBK-KL evaluates a person's line of thought. Based on the scoring guide on this indicator, the lowest score is 0 and the maximum is 5. Based on Figure 4.6, the pre-test score range on the small-scale test is 0.48, the large-scale test is 0.42, both of which are included in the very less critical category. The average result of both classes is 3.65, so that the limited scale test is included in the quite critical category. While in Figure 4.7 the post-test scores on the limited scale test of PIF B UTM and PIF D UTM classes are 3.40 and 3.33 both classes are included in quite critical. The results of the broad-scale test experienced an increase in the PIF A UTM score of 3.74 which was included in the moderately critical category, the PIF C UTM of 3.73 was included in the moderately critical category, UNILA PTI 4.36 was included in the critical category, and PIF IVET 4.90 was included in the very critical category.

The third KBK-KL indicator identifies unstated assumptions. Based on the scoring guide on this indicator, the lowest score is 0 and the maximum score is 6. Based on Figure 4.6, the pre-test score range on the small-scale test is 0.36, the large-scale test is 0.34 then both are included in the very less critical category. While in Figure 4.7 the post-test scores on the limited scale test of PIF B UTM and PIF D UTM classes are 4 and 4, both classes are classified as quite critical. The average result of the two classes is 4, so that the limited scale test is included in the quite critical category. The results of the broad-scale test experienced an increase in the PIF A UTM score of 4.56 which was included in the critical category, PIF C UTM of 4.65 was included in the critical category, PTI UNILA 4.76 was included in the critical category, and PIF IVET 4.7 was included in the critical category.

The fourth indicator of KBK-KL is predictive thinking. Based on the scoring guide on this indicator, the lowest score is 0 and the maximum score is 6. Based on Figure 4.6, the pre-test score range on the small-scale test is 0.58, the large-scale test is 0.68, so both are included in the very less critical category. While in Figure 4.7 the post-test score on the limited scale test for PIF B UTM class is 4 and PIF D UTM is 3.89 both classes are included in quite critical. The average result of the two classes is 3.94, so that the limited scale test is included in the quite critical category. The results of the broad-scale test experienced an increase in the PIF A UTM score of 4.7 including in the critical category, PIF C UTM by 4.77 in the critical category, PTI UNILA 4.84 in the critical category, and PIF IVET 4.9 in the critical category. The average result of the four classes is 4.80,

The fifth indicator KBK-KL handles label errors. Based on the scoring guide on this indicator, the lowest score is 0 and the maximum is 5. Based on Figure 4.6, the range of the pre-test scores on the small-scale test is 0.41, the large-scale test is 0.58, so both are included in the very less critical category. While in Figure 4.7 the post-test score on the limited scale test for the PIF B UTM class is 4.2 and the PIF D UTM is 3.89 both classes are included in the critical category. The average result of the two classes is 4.05 so that the limited scale test is included in the critical category. The results of the broad-scale test experienced an increase in the PIF A UTM score of 4.63 including in the very critical category, PIF C UTM of 4.73 including in the very critical category, PTI UNILA 4.76 including the very critical category, and PIF IVET 4.7 including in the very critical category.

The sixth indicator of KBK-KL is metacognitive thinking. Based on the scoring guide on this indicator, the lowest score is 0 and the maximum 6. Based on Figure 4.6, the pre-test score range on the small-scale test is 0.58, the large-scale test is 0.48, both of them are included in the very less critical category. While in Figure 4.7 the post-test score on the limited scale test for the PIF B UTM class is 3.6 and the PIF D UTM is 3.61 both classes are included in the fairly critical category. The average result of the two classes is 3.6 so that the limited scale test is included in the quite critical category. The results of the wide-scale test experienced an increase in the PIF A UTM score of 4.63 including in the critical category, PIF C UTM by 4.73 including in the critical category, PTI UNILA 4.6 including the critical category, and PIF IVET 4.4 included in the critical category.

The seventh indicator of KBK-KL solves problems in order. Based on the scoring guide on this indicator, the lowest score is 0 and the maximum 6. Based on Figure 4.6, the pre-test score range on the small-scale test is 0.58, the large-scale test is 0.48, both of them are included in the very less critical category. While in Figure 4.7 the post-test score on the limited scale test for the PIF B UTM class is 4 and the PIF D UTM is 3.73 both classes are included in the fairly critical category. The average result of both classes is 3.86 so that the limited scale test is included in the quite critical category. The results of the broad-scale test experienced an increase in the PIF A UTM score of 4.81 which was included in the critical category, PIF C UTM of 4.81 was included in the critical category, PTI UNILA 4.6 was included in the critical category, and PIF IVET 4.4 was included in the critical category.

Based on the analysis of the seven KBK-KL indicators that have been described, the classification of critical thinking ability levels on a large-scale test can be summarized in Table 4.21.

Table 4.21 Achieving the Critical Thinking Ability Level on the Wide Scale Test

Critical Thinking Ability Level	KBK-KL Indikator Indicators
Very Critical	Assess phenomena based on appropriate concepts Handling label errors
Critical	Evaluating a person's line of thought Predictive thinking

	Identify unstated assumptions
	Metacognitive thinking
	Solving problems in order

Based on Table 4.21 the impact of giving CLM and its supporting learning tools on the level of critical thinking ability of each KBK-KL indicator on a wide-scale test, minimum at the critical level and maximum at the very critical level. At the critical level, the KBK-KL indicators include evaluating a person's line of thought, predictive thinking, identifying unstated assumptions, metacognitive thinking, and solving problems sequentially. The maximum level is very critical on indicators assessing phenomena based on appropriate concepts and handling label errors.

c. KBK-KL N-Gain Consistency Effectiveness Test Analysis

The effectiveness test of the KBK-KL consistency was carried out to determine whether the provision of CLM learning interventions in both the limited-scale test and the wide-scale test experienced the same or different improvements. The effectiveness test was obtained by comparing the N-Gain data in the limited test class and the broad scale test class. Before the effectiveness test is carried out, it is necessary to carry out prerequisite tests, namely normality test, homogeneity test in the group to be measured using SPSS version 18.

1) Normality test

The N-Gain data for the limited-scale test on PIF B UTM and PIF D UTM classes as well as the broad-scale test consisting of PIF A UTM, PIF C UTM, PTI UNILA, PIF IVET classes were tested for normality using SPSS version 18, the results are shown in Table 4.22

Table 4.22 Kolmogorov-Smirnov. Normality Test

Group	Class	Sig.	Information
Limited Scale	PIF B UTM	0.013	Abnormal data
	PIF D UTM	0.075	Normal data
Wide Scale	PIF A	0.000	Abnormal data
	PIF C	0.000	Abnormal data
	PTI UNILA	0.000	Abnormal data
	PIFIVET	0.014	Abnormal data

Based on Table 4.22, the results show that in the limited scale class group KBK-KL PIF B UTM the N-Gain data is not normally distributed, PIF D UTM is normally distributed. While the test results in the broad-scale class group showed that the significance values for both PIF A, PIFC, PTI Unila, PIF IVET, N-Gain data were not normally distributed.

2) Homogeneity Test

Examination of the assumption of homogeneity of variance was carried out using Levene's test. Levene's test is a method of testing the homogeneity of variance with the data being tested does not have to be normally distributed. The homogeneity test is used to determine whether the N-Gain score for both the limited-scale class group and the broad-scale class group is homogeneous or not. The results of the homogeneity test are shown in Table 4.23.

Table 4.23 Levene Homo Homogeneity Test

Class Group	Class	Sig.	Information
Limited Scale	PIF B UTM	0.711	Homogeneous data
	PIF D UTM		
Wide Scale	PIF A UTM	0.464	Homogeneous data

Class Group	Class	Sig.	Information
	PIF C UTM		
	PTI UNILA		
	PIFIVET		

Based on Table 4.23 the output results of "Test of Homogeneity of Variances" it is known that the significance value (Sig.) for the limited-scale class group has a significance of 0.711 > 0.05, so it can be concluded that the data variance is the same or homogeneous. Likewise, the broad-scale class group with a significance of 0.464 > 0.05, it is concluded that the data variance is the same or homogeneous.

3) N-Gain Equal Effectiveness Equivalence Test

Both the limited-scale class group and the broad-scale group data, the N-Gain score was only one data that was normally distributed, the five data groups showed abnormality. Although all data are homogeneously distributed, not all data are normally distributed, so to test the effectiveness of the N-Gain similarity using a non-parametric test. In the limited-scale class group, 2 independent samples were used with the Mann-Whitney Test. Meanwhile, the broad-scale class group was tested using the ANOVA K independent sample test with the Kruskal Wallis Test type of test. Take into account both the Mann-Whitney Test and the Kruskal Wallis Test using SPSS version 18. The test results are shown in Table 4.24.

Table 4.24 Equality Test of KBK-KL N-Gain Effectiveness

Class Group	Class	Test Type	Sig.	Conclusion
Limited Scale	PIF B UTM		0.71	No difference

Class Group	Class	Test Type	Sig.	Conclusion
	PIF D UTM	*Mann-Whitney Test*		
Wide Scale	PIF A UTM	*Kruskal Wallis Test*	0.53	No difference
	PIF C UTM			
	PTI UNILA			
	PIFIVET			

Based on Table 4.24, 2 independent sample tests using the Mann-Whitney Test obtained a significance value of 0.712 > 0.05. It can be concluded that CLM and learning tools have the same effect of increasing the N-Gain KBK-KL in the limited-scale class group, namely PIF B UTM and PIF D UTM. Likewise, the results of the Kruskal Wallis Test obtained a significance value of 0.53 > 0.05. It can be concluded that CLM and learning tools have the same effect on increasing the N-Gain of KBK-KL in large-scale class groups, namely PIF A UTM, PIF C UTM, PTI UNILA, and PIF IVET.

2. Student Response

Student response data was obtained from filling out student response questionnaires after obtaining CLM interventions and learning tools. The student response questionnaire consists of three components, namely student textbooks, CLM learning and student self-confidence in KBK-KL. Categorization of student responses consists of very weak, weak, moderate, strong, and very strong(Riduwan, 2010).The results of the calculation of student response questionnaires, CLM and learning tools can be effective if at least in the strong category, namely the score range (60%-80%). Aspects of student responses to textbooks are shown in Figure 4.8.

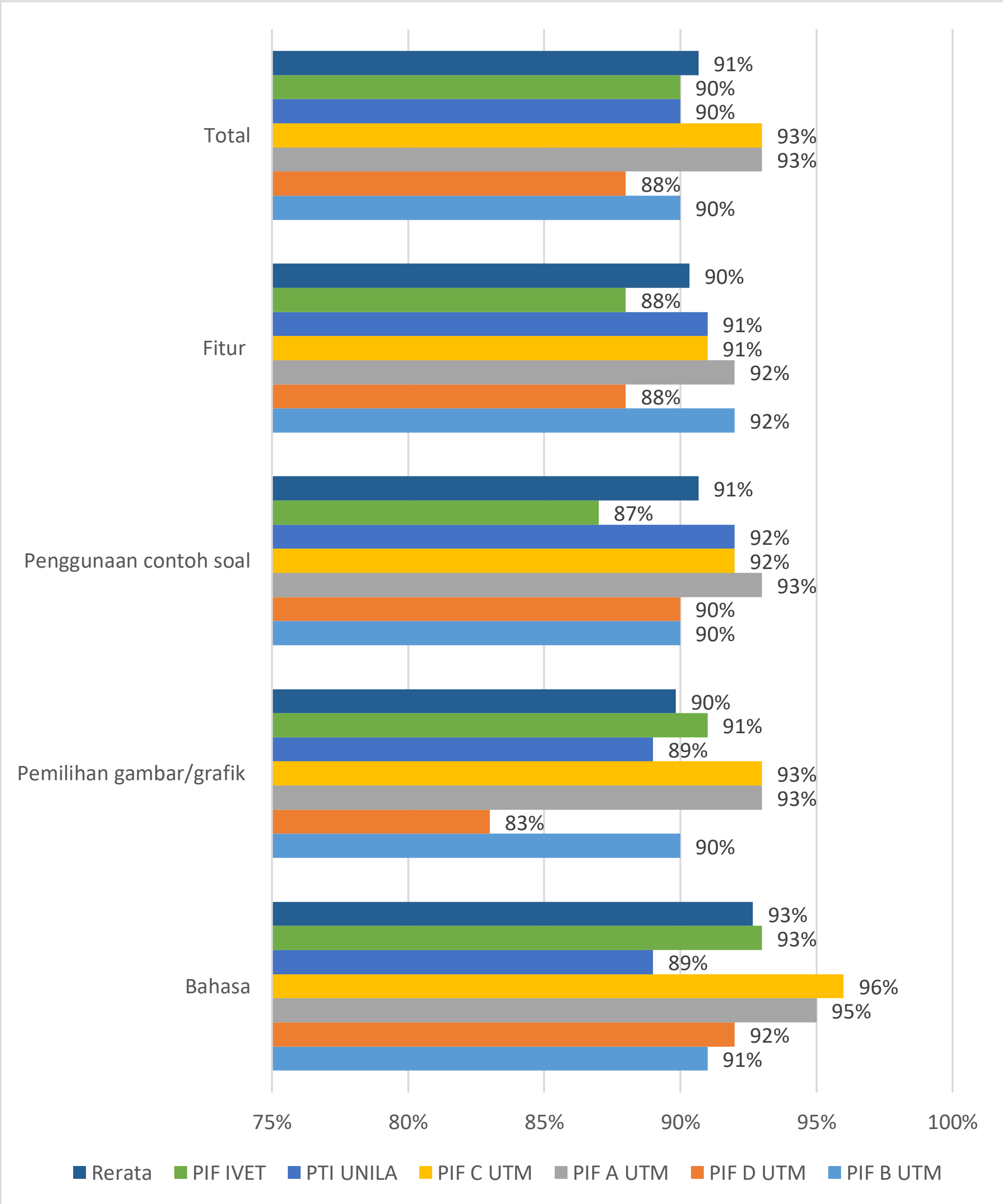

Figure 4.8 Student Response to Student Textbooks

Based on Figure 4.8 on the language aspect, all classes are included in the category of very strong response. Likewise, the results of the average calculation in this aspect of 93% are included in the very strong response category. The results of the calculation of the aspect of the selection of images/graphics, all classes are included in the category of very strong response. Likewise, the results of the average calculation in this aspect of 90% are included in the very strong response category. The results of the calculation of aspects of the use of questions, all classes are included in the category of very strong responses. Likewise, the results of the average calculation in this aspect of 91% are included in the very strong response category. The results of the calculation of the feature aspect, all classes are included in the very strong response category. Likewise, the results of the average calculation in this aspect of 91% are included in the very strong response category.

Measurement of student responses to the second component, namely CLM learning. Aspects that are measured include giving authentic problems, investigations, reasoning tasks, lecturer guidance and giving quizzes, and reflection. The measurement results on the CLM learning component are shown in Figure 4.9.

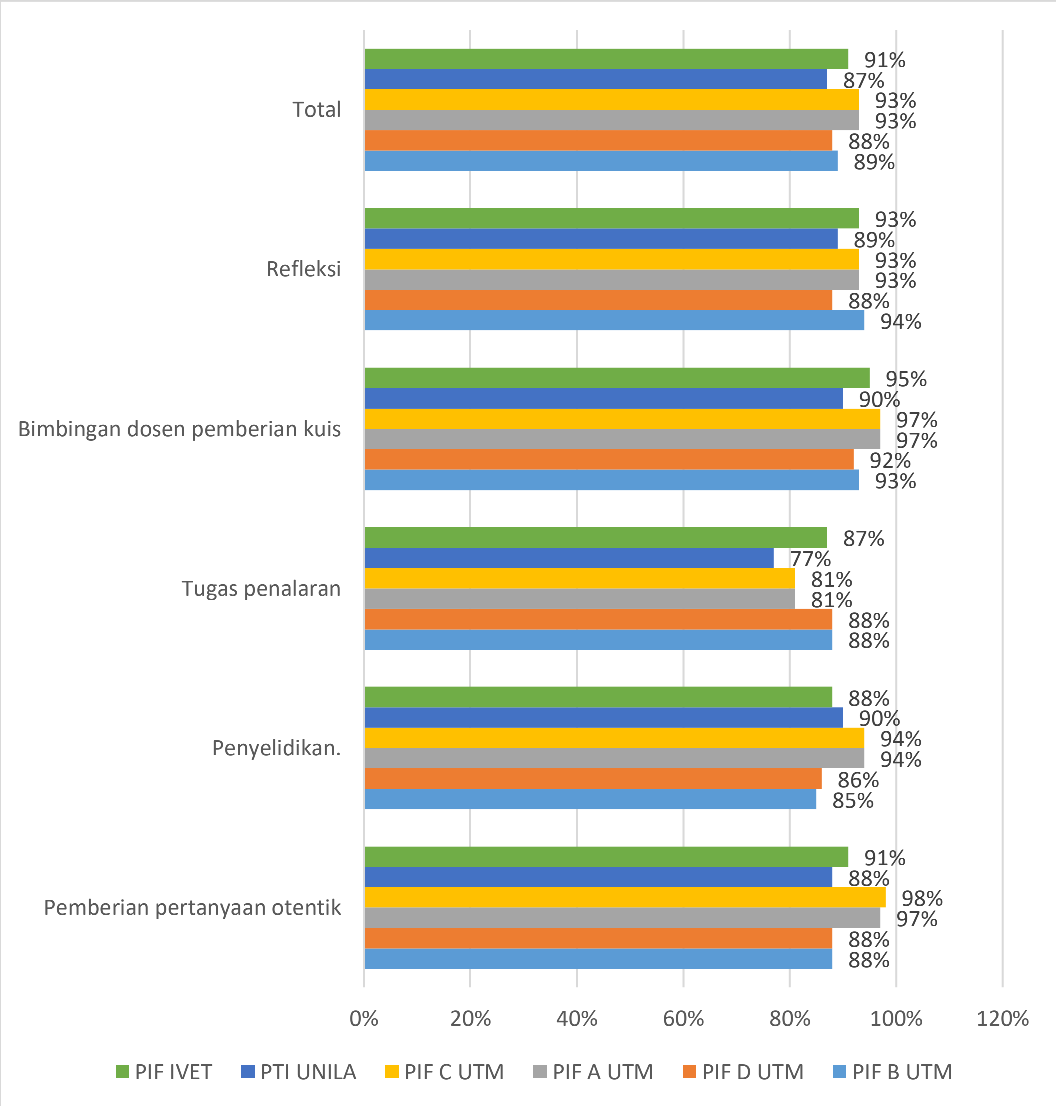

Figure 4.9 Student Response to CLM

Based on Figure 4.9 on the aspect of giving authentic questions, all classes are included in the category of very strong responses. Likewise, the results of the average calculation in this aspect of 91% are included in the very strong response category. The results of the calculation of the investigation aspect, all classes are included in the category of very strong response. Likewise, the results of the average calculation in this aspect of 88% are included in the very strong response category. The results of the calculation of the aspect of the reasoning task, one class is included in the strong category and five classes in the very strong response category. The average calculation in this aspect of 88% is included in the very strong response category. The results of the calculation of aspects of lecturer guidance and quizzes, all classes are included in the category of very strong response. Likewise, the results of the average calculation in this aspect of 95% are included in the very strong response category. The results of the reflection calculation, all classes are included in the category of very strong response. Likewise, the results of the average calculation in this aspect of 93% are included in the very strong response category. The average result of the total components of 91% is included in the very strong category.

The results of the calculation of the total average of the CLM learning components which include aspects of giving authentic problems, investigations, reasoning tasks, lecturer guidance and giving quizzes, and reflections show that all classes are in the very strong category. The lowest percentage in the reasoning aspect is 87% and the highest percentage is in the guidance of lecturers and giving quizzes by 95%. The results obtained are able to exceed the minimum limit of effectiveness (60%-80%), so it can be concluded that CLM learning is effective for improving KBK-KL.

Measurement of student responses to the third component, namely self-confidence to KBK-KL. Aspects that are measured include the ability to relate the problem to the right concept, the ability to reason, and the ability to make explanations. The measurement results on the CLM learning component are shown in Figure 4.10.

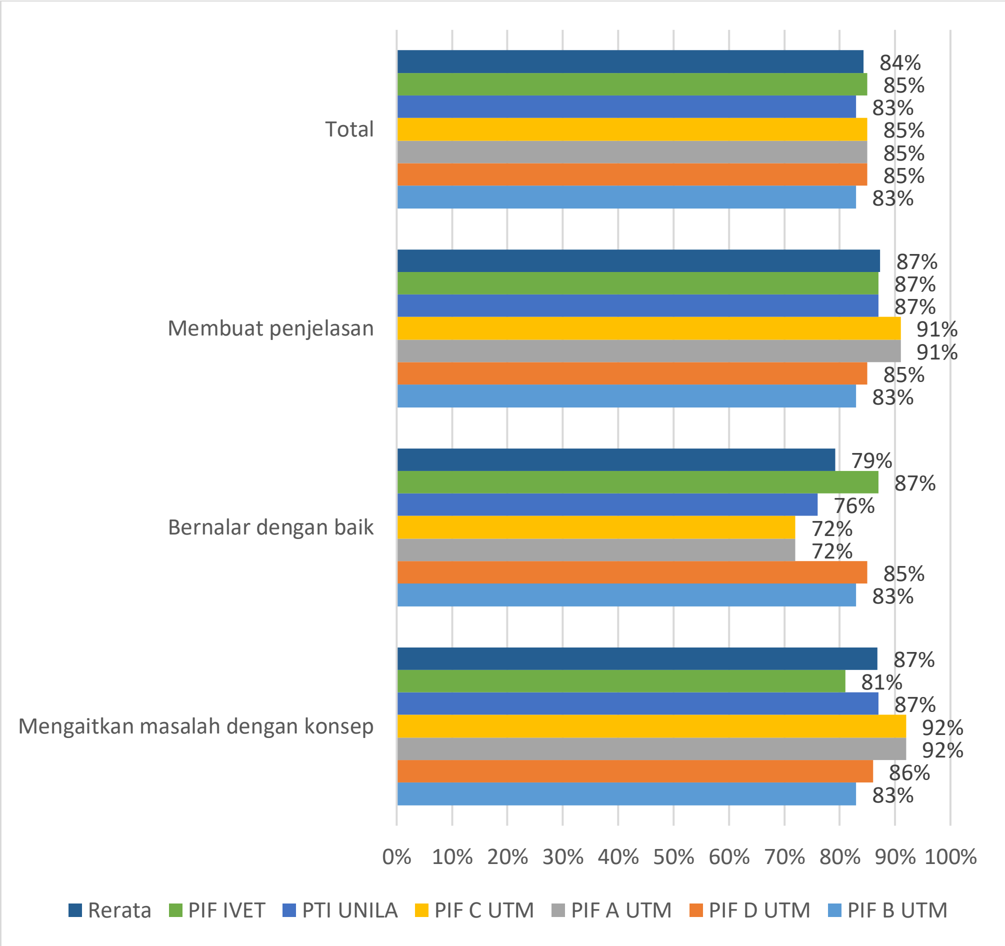

Figure 4.10 Student Response to KBK-KL Keyakinan Beliefs

Based on Figure 4.10 on the aspect of relating the problem to the right concept, all classes are included in the category of very strong response. Likewise, the results of the average calculation in this aspect of 87% are included in the very strong response category. The results of the calculation of the aspect of reasoning well, the lowest percentage of 72% is included in the strong category, namely in the PIF A UTM and PIF C UTM classes and the highest at 87% is included in the very strong category for the PIF IVET class assessment. The results of the calculation of aspects make explanations, all classes are included in the category of very strong responses. Likewise, the results of the average calculation in this aspect of 87% are included in the very strong response category. The average result of the total components of 84% is included in the very strong category.

CHAPTER V
DISCUSSION OF RESEARCH RESULTS

Discussion ABOUT results of the study aim to discuss the results of the study which include the validity, practicality, and effectiveness of CLM. The research data will be described so that it can determine the achievement of research objectives. The details of the discussion are described as follows.

A. CLM Validity and Learning Tools

1. CLM Validity

CLM validity consists of content and construct validity. Content validity was measured by three validators covering three aspects, namely aspects of the need for CLM development, aspects of state-of-the-art knowledge, aspects of model components. Based on Table 4.3, the results of the CLM content validity assessment show that the average score for both aspects of CLM development needs, state of the art knowledge, and model components has a value of 3.8. Thus, it can be concluded that the content validity of the CLM is included in the very valid category and does not need revision (Akhdinirwanto *et al.*, 2020; Ratumanan & Laurens, 2006). These results are reinforced by the calculation of the percentage of agreement, the results show that the percentage level of aspects of CLM development needs is 93%, the state-of-the-art knowledge aspect is 97%, the model component aspect is 100%. Thus, the percentage of agreement level has exceeded

75% so that it can be concluded that the validity of the CLM content is reliable (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006).

Content validity is included in the very valid category, meaning that the CLM design made in the form of a model book includes aspects of CLM development needs, aspects of state-of-the-art knowledge, and component aspects of the model that have fulfilled all the elements of the criteria for developing learning models. While the reliable category means that the three validators in assessing the validity of the content of CLM are not much different or have consistent results.

Based on Table 4.3 the design of CLM in the aspect of learning development needs consists of four indicators that are assessed by experts. The first indicator supports the achievement of the study program profile. The second indicator supports the achievement of the IQF. The third indicator is the need for 21st century learning. The fourth indicator is the provision to face the VUCA era which stands for volatility (volatility), uncertainty (uncertainty), complexity (complexity), and ambiguity (ambiguity).

The profile of graduates of the Informatics Education Study Program includes educators, experts, educational staff and professional technopreneurs, so critical thinking skills are needed. Achieving professionalism in work requires various abilities, one of which is critical thinking (Bassham & Wallace, 2013; Ennis, 2016), Facione & Gitten, 2016; Winch & Gingell, 2008). The role of critical thinking skills is to optimize intellectual capacity to get the best decisions (Davies, 2015; Ennis, 2016).

In addition, critical thinking skills also support the achievement of general skills of the Informatics Education Study Program contained in the AchievementsTechnology Vocational Education GraduateinformationNational Standards for Higher Education (Permendikbud, 2014). The general skills contain the following:

1. able to apply logical, critical, systematic, and innovative thinking in the context of the development or implementation of science and technology that pays attention to and applies the value of local wisdom in accordance with their field of expertise;
2. able to demonstrate independent, quality, and measurable performance;
3. able to examine the implications of the development or implementation of science and technology that pays attention to and applies the value of local wisdom in accordance with their expertise based on scientific principles, procedures and ethics in order to produce solutions, ideas, designs or art criticism, compile scientific descriptions of the results of their studies in the form of a thesis or assignment report end, and upload it on the college website;
4. able to make appropriate decisions in the context of solving problems in their area of expertise, based on the results of information and data analysis;

The second aspect of the need for CLM development is to support the achievement of the KKNI. The main purpose of designing CLM is to train, and improve KBK-KL for students. The taxonomy of critical thinking skills, in the KBK-KL component, shows that students are required to optimize their intellectual abilities, so that they get the best decisions and have the ability to make explanations of the decisions that have been taken (Davies, 2015; Ennis, 2015). This ability will support the character of a person with professional performance (Facione, 2016; Wallace, 2001). Thus KBK-KL is relevant to the purpose of providing higher education in undergraduate programs in higher education to prepare students to become intellectuals and/or scientists who are cultured, and have competitiveness so that they are able to work professionally. (Ministry of Education and Culture 2012, Article 18:2). Explanation Special Regarding the learning objectives of higher education are contained in the IQF.

Learning outcomes with a bachelor's degree based on the KKNI are equivalent to qualification level 6 (Presidential Regulation of the Republic of Indonesia, 2012) which includes:

1. Ability to solve problems encountered by using the field of knowledge that has been owned.
2. The ability to formulate procedural problems through certain theoretical concepts that he has mastered in depth.
3. Able to make decisions by paying attention to information from various alternative solutions, both independently and in groups.
4. Have an attitude of responsibility at work alone or in groups.

Based on the content of the objectives of the undergraduate program, the skills needed are problem solving, formulating problems with concepts possessed and the ability to make appropriate decisions based on information and data analysis, and being able to provide instructions in choosing various alternative solutions are characteristics of KBK-KL. This is because KBK-KL requires someone to be able to evaluate facts or phenomena, predict, and work sequentially using the knowledge they have.

The third aspect of the need for CLM development is the learning needs of the 21st century. The results of the assessment on this aspect obtained an average of 4 included in the very valid category with a percentage of agreement of 86% (Table 4.3). Thus, it can be concluded that the design of CLM is a valid learning need for the 21st century. The planning is as follows.

CLM was developed to train KBK-K's critical thinking skills. Critical thinking skills are one of the important skills in 21st century society. As the contents of the partnership for 21st century skills, there are four important components, namely critical thinking skills, problem solving, collaboration, communication, creative thinking, digital literacy and mastery of information and communication technology (Charles & Trilling, 2009; Frydenberg & Andone, 2011).

ActivityCLM learning involves several information technologies which are part of the needs of the 21st century community. Because CLM has two forms, face-to-face synchronously, facilitated by technology using a video conference learning platform, is the main characteristic of distance learning. (Jung & Richter, 2019; Sewart, 2014). The purpose of this technology is to facilitate students to interact directly (Seemiller & Grace, 2016). Interaction will strengthen an important factor in distance learning, namely learning motivation (Anjana, 2018), and facilitating social factors that are owned by every human individual (Hartnett, 2016). Another technology used is the Learning Management System (LMS) as a medium for sending learning resources such as textbooks, Phet Simulation programs, sending action plan sheets, this will streamline the learning process and objectives (Pratama *et al.*, 2020).

The third aspect of the need for CLM development is provision to face the VUCA era which stands for volatility (volatility), uncertainty (uncertainty), complexity (complexity), and ambiguity (ambiguity). The development of CLM with the aim of increasing critical thinking skills, especially KBK-KL is an ability required by current conditions with the characteristics of volatility (uncertainty),

uncertainty (uncertainty), complexity (complex), and Ambiguity (unclear) or often referred to as VUCA (Raghuramapatruni). & Kosuri, 2017). The role of critical thinking skills in the VUCA era is to provide an assessment of facts or information processed by a robotic system as the basis for improving the results of the work done (Guo & Cheng, 2019). The results of other studies show that critical thinking skills are useful for solving problems in various situations, even new situations that have never happened before (Raghuramapatruni & Kosuri, 2017; Poernomo, 2020). Another benefit is as a basis for precise and accurate decision making (Amelia *et al*., 2019). Thus, critical thinking skills are needed by students to face challenges in the VUCA era.

In addition to having fulfilled aspects of learning development needs, the design of CLM has also fulfilled aspects of state-of-the-art knowledge. Indicators in this aspect include CLM updates, empirical studies of CLM development, CLM planning according to 21st century learning needs, and the CLM learning environment. The results of the assessment on this aspect obtained an average of 3.8 included in the very valid category with a percentage of agreement 97% (Table 4.3). Thus, it can be concluded that the CLM design has met the state-of-the-art knowledge and is valid. The planning is as follows.

The main basis of the novelty of CLM is that it focuses on measuring advanced clarification critical thinking skills, then it is strengthened that there is no inquiry-based learning intervention to measure all indicators of advanced clarification critical thinking skills consisting of seven indicators as shown in Figure

2.2. The second novelty lies in the syntax or the learning phase, this is shown in Figure 2.3. and CL has distinctive value in communication patterns.

The first novelty of CLM focuses on improving critical thinking ability on advanced clarification. Many learning models have contributed to improving critical thinking skills. However, the critical thinking skills developed by Ennis (2016) on the advanced clarification component are not yet fully optimal. The learning models are problem-based learning or PBL (Mundilarto & Ismoyo, 2017; Awan *et al*., 2017), project-based learning models or PjbL (Sumarni & Kadarwati, 2020; and Taufiq *et al*., 2020), inquiry learning models or IBL (Irwanto *et al*., 2018; Zain & Jumadi, 2018; Herawati *et al*., 2020; Pursitasari *et al*., 2020; Prayogi & Verawati, 2020), learning model Structuring a new Socioscientific Issues (Davut Gul & Akcay, 2020) and the FERA learning model, namely Focus, Explore, Reflect and Apply (Diani *et al*., 2020).

CLM was developed to improve critical thinking ability on advanced clarification. This is described as a learning model that will measure all indicators of critical thinking ability on advanced clarification consisting of seven indicators. The indicators of critical thinking ability for advanced clarification include defining terms, and assessing definitions based on appropriate criteria, handling misunderstandings appropriately, identifying unstated assumptions, suppositional thinking (estimations), handling wrong claims, metacognitive thinking, and solving problems sequentially.

However, based on a study of the inquiry learning model as the basis for developing CLM, data was obtained that it was only used to measure two indicators.

First, define terms and assess definitions based on appropriate criteria (Irwanto *et al*., 2018; Zain & Jumadi, 2018; Rahmi *et al*., 2019; Herawati *et al*., 2020; Maknun, 2020; Pursitasari *et al*., 2020). The second indicator is identifying unstated assumptions (Irwanto *et al*., 2018; Herawati *et al*., 2020; Maknun, 2020; and Purwitasari *et al*., 2020).

The second novelty lies in the syntax or phase. Limited information from the study of research results, the researchers set an inquiry model developed byArend, (2008) and Joyce *et al*., 2009) as the basis for model development. The difference in syntax or learning phase is shown in Figure 2.3. The CLM syntax was developed to strengthen the query syntax (Arend, 2008; Joyce *et al*., 2009), the difference between the two lies in the third and third syntax. fourthCLM. The following comparison of inquiry learning with CLM is shown in Table 2.9.

The third syntax is reasoning, this becomes a new phase based on the evaluation results that students have difficulty connecting their knowledge with the types of questions asked. (Sumarni & Kadarwati, 2020). The concept of reasoning needs to be strengthened because critical thinking skills are good reasoning skills based on evidence (Ennis, 1985a; Halpern, 1999; McPeck, 1981; Siegel, 1991). Reasoning tasks can improve critical thinking skills (Saputro, Arifin, *et al*., 2020; Roberson & Franchini, 2014; Wang *et al*., 2019).

The second difference is in the 4th syntax, namely clarification and evaluation, this is due to the factors that cause low critical thinking skills in critical thinking skills, advanced clarification is unfamiliar with the type of questions (Pradana & Parno, 2017; Sumarni & Kadarwati, 2020; Herunata *et al*.., 2020; Herawati *et al*., 2020). So, students need additional questions to get used to solving various problems. This phase facilitates students to practice again through evaluation, this is because the lecturer wants to confirm their abilities through additional questions or tests. This activity takes place synchronously due to the need for guidance in training (Halpern, 2014); Herunata *et al*., 2020).

CLMhavedistinctive value in communication patterns. The role of the lecturer in this model is necessary to emphasize on the characteristics of students as learners who are teenagers and generation Z with their peculiarities. This is shown in the first phase, namely the orientation of the activity steps to involve students in optimizing task completion, this is in accordance with the character of adolescent learners who want to be involved in decision making (Garry *et al*., 2013).

Generation Z characters are realistic in action, they will be motivated if there is a benefit to be gained (Seemiller & Grace, 2016). So that at the beginning of a face-to-face meeting, a lecturer needs to show the relationship between the material and the career world. The next thing that really stands out is putting forward concern for Gen Z students, they like to be cared for and care about other people's activities (Yu, 2016; Miller, 2019). In its implementation, a lecturer needs to say hello by name with several things that touch positive feelings, such as related to hobbies when interacting in virtual classes.

The CLM design was developed based on the component model. Indicators on aspects include CLM focused on the goal of increasing the KBK-KL. The theory used by CLM is supported according to educational theory. Activity guide for lecturers and students in CLM. CLM allows for a social system. The principle of the CLM reaction. Supporters in CLM such as facilities, materials, tools for the learning process are clearly stated. Activities designed in each phase in the CLM syntax can support the achievement of instructional goals. Activities designed in

CLM have the potential to have accompaniment impacts. The results of the assessment on this aspect obtained an average of 3.8 included in the very valid category with a 100% percentage of agreement (Table 4.3). Thus, it can be concluded that the CLM design has met the model components and is valid.

The development of CLM is to improve the KBK-KL which consists of seven indicators (Ennis, 2015). CLM has 5 main phases, namely learning orientation, inquiry, reasoning, clarification and evaluation, and reflection. The learning orientation phase aims to develop KBK-KL on indicators of metacognitive thinking. Phase 2 of the investigation aims to develop KBK-KL on indicators identifying unstated assumptions and solving problems in order. Phase 3 reasoning aims to develop KBK-KL on predictive thinking indicators and handle label errors. Phase 4 of clarification and evaluation aims to develop KBK-KL on indicators of assessing phenomena based on appropriate concepts and evaluating one's line of thought. Phase 5 of reflection aims to develop KBK-KL on indicators of metacognitive thinking.

Learning to practice critical thinking skills requires special designs with various forms of activities, such as analyzing, comparing and other activities (Stephen Johnson; Harvey Siegel, 2010). This opinion is reinforced by McPeck (2017), namely the ability to think critically is a skill, so it can be taught through a certain training. Critical thinkers only provide signs for teaching critical thinking skills in general, namely learning can be done through a problem-solving process (Ennis, 2015; Facione & Gitten, 2016).

Physics is a part of natural science that discusses natural phenomena that have an impact as a science that builds critical thinking and investigation methods (Koballa, 2010). The concept of physics can be obtained through analytical and observational approaches. Physical products are the result of processes in the form of: facts, concepts, principles, theories, and laws (Ibrahim, 2012). Learning concepts based on the reality that is around us will have an impact on future readiness (Bueche & Hecht, 2006). In addition, through mastery of concepts it can be applied for various purposes, through: manipulation or material manipulation through creative ideas (Suyido, *et al*., 2020). CLM developed using constructivist theory, intellectual development, discovery learning, learning mean, social constructivism, and metacognition theory.

Next CLM allows for a social system in phase-1 learning orientation, and phase-4 clarification and evaluation. This is indicated by mentioning names, and thanking students for their presence. This is based on the results of research which states that Generation Z respects people who know themselves (Yu, 2016; Miller, 2019). Likewise, the curriculum that needs to be considered for distance learning is inclusive, one of which pays attention to their background (Reinholz *et al*., 2020).

The pattern of communication during discussions between lecturers and students in phase 4 of clarification and evaluation, and discussions during phase 2 with fellow students emphasizes open intellectuality. This is due as adult learners accept knowledge of reason and evidence (Upton & Trapp, 2010:68; Slavin, 2011:54). As the main characteristic in critical thinking skills, acceptance of an idea is not based on age level but based on rationality based on evidence (Ennis, 1985a; Halpern, 1999; McPeck, 1981; Siegel, 1991).

Patterncommunicationlecturers and students prioritize caring. namely in phase-1 orientation and phase -4 clarification and evaluation, the lecturer asks all students whether what has been conveyed has been understood or not. So, the role of the lecturer is as a guide, moderator, facilitator, evaluator and creates a comfortable atmosphere when learning takes place. There are many obstacles experienced by students during distance learning, so as a teacher it is necessary to show an open attitude to students to provide learning services (Anjana, 2018; Bork & Gunnarsdottir, 2001). The paradigm of facilitating learning to students needs to be prioritized in distance learning (Danjou, 2020).

The principle of this reaction contained in CLM is as follows: teachers should not be rigid, we must care about the condition of each learner (Barry & Kanematsu, 2020; Dew *et al*., 2020; Karakaya *et al*., 2020). Lecturers give polls to students to obtain data on difficulties faced by students when doing independent assignments. The data from the poll was followed up by emphasizing material that was still included in the difficult category by students.

Phase-4 clarification and evaluation contains an activity to evaluate group work reports and independent assignments. Lecturers will give appreciation to students who have worked hard while completing the learning bill which is delivered directly via video conference. In addition, the lecturer will also provide confirmation for concepts that are still considered difficult by students. So that students have the same perception, the lecturer gives students the opportunity to ask questions if there is ambiguity in the delivery of the lecturer. With social interaction, it will spur the development of new ideas and increase intellectual development or the Zone of Proximal Development (ZPD) (Arend, 2008; Slavin, 2011).The paradigm of facilitating learning to students needs to be prioritized in distance learning (Danjou, 2020).

Paid Phase-5 students collect action plan reflection sheets and mind map charts will be responded back by the lecturers through the delivery of information via social media whatsapp. Through the principle of reaction in CLM will strengthen the achievement of learning objectives, namely the ability to think critically for advanced clarification.

The support system found in CLMcoversRPS, SAP, student textbooks, KBK-KL tests, learning constraint sheets, and student response questionnaires are available. In the application of CLM, an online learning platform is needed, such as zoom meetings for video conferences, LMS as a learning resource can be filled with CLM learning tools, Phet Interactive Simulations software, video tutorials and so on. Other supporting materials such as laptops, LCDs, electricity networks, and smooth internet networks. The availability of examples of completion of further clarifying critical thinking ability test items in Textbooks can provide inspiration for students in doing reasoning tasks in phase-and quizzes in phase-4.

Impact Accompaniment Is another learning result created from the learning process experienced during the CLM learning process, namely the LMS learning media will form learning independence. Phase-1: learning orientation, there is an assignment to make action plans and phase-5 reflection on action plans, this will train metacognition skills. Phase-2: inquiry with group formation will develop good communication and cooperation in all situations. Phase-2: investigation of practicum reports in the form of posters, phase-4: clarification and evaluation of the presentation of results and phase-5: reflection on making mind map charts, will train skills multiple representation. Phase-3: reasoning it is expected that students will optimize every resource they have, both notebooks and the use of technology to be able to complete assignments on target, this will develop problem solving skills. The use of various platforms such as video conferencing, LMS, and making posters will also train digital literacy skills.

The measurement of construct validity includes five aspects, namely an overview of CLM, conformity with theoretical and empirical support, planning and implementation, learning environment, assessment and evaluation. Based on Table 4.4 the results of the CLM construct validity assessment, the results show that the average score is good on the CLM overview aspect, conformity with theoretical and empirical support, planning and implementation, learning environment, assessment and evaluation has a score range (3.5-4). Thus, it can be concluded that construct validity is included in the very valid category and does not need revision (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006). The results of the calculation of the percentage of agreement in the CLM overview aspect are 96%, the conformity aspect with theoretical and empirical support is 97%, planning and implementation aspects are 100%. The suitability aspect with theoretical and empirical support is 97%, the learning environment aspect is 93%, and the assessment and evaluation aspect is 100%. Thus, the percentage of agreement level exceeds 75% so it can be concluded that the validity of the CLM construct is reliable (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006).

Construct validity is included in the very valid category, meaning that the CLM development structure is made in the form of a model book, both aspects of CLM overview, conformity with theoretical and empirical support, planning and implementation, learning environment, assessment and evaluation between interrelated components, between components with good evidence theoretically and empirically factually. While construct validity has a reliable category, meaning that the three validators in assessing the validity of the CLM construct are not much different or have consistent results.

CLM is developed based on the profile needs of graduates to become professional educators, experts, education staff and technopreneurs through the development of KBK-KL. Each phase of the CLM syntax has been supported by theoretical studies and empirical facts. Phase-1: Learning orientation. PhaseIn this, students will be presented with authentic problems, delivery of goals, mutual agreement. This activity strengthens the problem presentation phase in the inquiry model (Arend, 2008). This phase was chosen based on previous research suggestions which stated that through presenting authentic problems it could provide a stimulus for critical thinking skills (Mundilarto & Ismoyo, 2017; Kadarwati 2020; Rahmi *et al*., 2019; Diani *et al*., 2020). The right step for students to construct knowledge is through an event(Ray, 2002; Chang, 2005).In cognitive theory, any given phenomenon will be responded to through organizing the knowledge that has been possessed (schemata) which is called assimilation (Arend, 2008; Moreno, 2010).Providing information on the purpose of problem solving to achieve certain learning objectives, so that in order to be maximal in achieving student goals, students make lesson plans implementing metacognitive theory(Moreno, 2010).

Activity Learning is carried out face-to-face synchronously, facilitated by technology using a video conference learning platform, which is the main characteristic of distance learning (Jung & Richter, 2019; Sewart, 2014). The purpose of this technology is to facilitate students to interact directly (Seemiller & Grace, 2016). Interaction will strengthen an important factor in distance learning, namely learning motivation (Anjana, 2018), and facilitating social factors that are owned by every human individual (Hartnett, 2016). Another technology used is the Learning Management System (LMS) as a medium for sending learning resources such as textbooks, Phet Simulation programs, sending action plan sheets, this will streamline the learning process and objectives (Pratama *et al*., 2020).

The learning objectives are related to the benefits that will be obtained for the field of informatics, this is because generation Z students are very realistic in thinking (Seemiller & Grace, 2016). Students want to apply the theory they already have to solve problems in the world of work (Purcell & Purcell, 2019). So that it will foster motivation and interest in learning for each student (Hidayat & Wibawa, 2020).

DesignPhase 1 learning begins with questions, delivery of clear learning objectives, taking into account student characteristics, and distance learning success factors, notification of learning objectivesactivityThis was the purpose of trainingKBK-KL on metacognitive thinking indicators.

Phase-2: Investigation.ActivityThe investigation includes determining hypotheses, collecting data through experiments, concluding that they are carried out in groups. This activity combines the phases of data verification, hypothesis, data collection and explanation of the inquiry model (Arend, 2008). This phase is the implementation of the essence of critical thinking skills: process thinking rationally with appropriate explanations based on evidence (Ennis, 1985a; Halpern, 1999; McPeck, 1981; Siegel, 1991). This activity is also based on research suggestions which contain that it is necessary to hypothesize and prove hypotheses to build one's critical thinking skills (Mundilarto & Ismoyo, 2017; Kadarwati 2020; Rahmi *et al*., 2019; Diani *et al*., 2020).

In theory of learning, the process of inquiry can optimize one's cognitive participation such as analysis, interpretation, inference and sharing activities number construct knowledge (Chang, 2005). Investigation is a cognitive process that builds knowledge through matching new data or situations to existing schemata to develop new concepts or schemata called accommodation (Arend, 2008; Moreno, 2010). It is the basis of discovery learning theory, namely the concept is not the result of giving but needs to be discovered by students (Moreno, 2010). The emphasis on learning needs to emphasize inductive reasoning and the process of inquiry (Arend, 2008; Slavin, 2011). Activities that involve the five senses, thinking and actively conducting experiments will be able to form students' knowledge independently (Arend, 2012). Group activities are the application of social constructivist theory of scaffolding in learning (Moreno, 2010).

Practical activities in groups facilitate generationZ in being an open person through interactions in interactive communication patterns (Seemiller & Grace, 2016; Fernández & Fernández, 2016). Besides that, group activities will optimize the involvement of students in activities learning so that the learning objectives can be effective (Baber, 2020). Discussion activities are the character of adult learners because knowledge is acceptable based on reasons and evidence (Upton & Trapp, 2010; Slavin, 2011).

Technology Distance learning using a video conference learning platform as a discussion medium (Jung & Richter, 2019; Sewart, 2014). The purpose of this technology is to facilitate students to interact directly (Seemiller & Grace, 20169). Another technology used is the Learning Management System (LMS) as a medium for sending assignments in the form of practicum reports and posters that will streamline learning objectives (Pratama *et al*., (2020). The assignment of advanced organizers can improve critical thinking skills (Prayogi & Verawati, 2020) and learning outcomes (Saputro *et al*., 2014).

The learning design in the investigation phase which contains hypothetical activities aims to train critical thinking ability on advanced clarification in the form of indicators for identifying assumptions that are not stated, predictive thinking. Practical activities to make conclusions, and discuss the results of the investigation aimed at training KBK-KL on indicators of metacognitive thinking identify unstated assumptions and solve problems in order.

Phase-3: Reasoning.Activities In the form of working on independent tasks containing elaboration and practice questions, this is the implementation of research suggestions that contain the need for guided exercises (Diani *et al*., 2020; Herunata *et al*., 2020). Guidance in this phase is in the form of a textbook guide that is structured with a certain structure to clarify the study material (Bork & Gunnarsdottir, 2001:165; Aljanazrah, 2020). This activity is expected to be able to minimize the non-optimal critical thinking skills classification advanced caused by the low reasoning ability of learners (Pradana & Parno, 2017; Sumarni & Kadarwati, 2020; Herunata *et al*., 2020; and Herawati *et al*., 2020). Low initial ability as the basis of reasoning (Herunata *et al*., 2020), will be minimized through elaboration of tasks that are guided in student textbooks aimed at strengthening the knowledge that has been obtained (Moreno, 2010; Slavin, 2011).

Next Weak Linking the problems encountered with the use of appropriate concepts (Sumarni & Kadarwati, 2020), will be minimized through textbook instructions to find the right concept in solving problems (Saputro, Arifin, *et al*., 2020; Roberson & Franchini, 2014; and Wang *et al*., 2019). The low ability to describe concepts (Pradana & Parno, 2017; Sumarni & Kadarwati, 2020; Herunata *et al*., 2020; and Herawati *et al*., 2020) will be facilitated in textbooks through written language representation activities (Herawati *et al*., 2020).

Learning theory foundation meaningful learning that is associating new information with information of others who saved memory for a long time (Moreno, 2010; Tomei, 2010; Slavin, 2011). Reinforced by cognitive theory that contains the formation of new schemata through asking questions, and making efforts to find answers matching what they have found with their predictions, comparing their findings with the findings of other friends (Arend, 2008). When completing tasks independently, students actively carry out the reasoning process to re-conceptualize the knowledge gained through experimentation, which is the application of cognitive constructivist theory (Aunurahman, 2009).

The technology used is the Learning Management System (LMS) as a medium for sending independent assignments to streamline learning objectives (Pratama *et al*., 2020). In addition, it is a tool for detecting abilities and measuring abilities possessed by students.so that it can be used for determining learning policies (Hoq, 2020). Also pay attention to the habits of Generation Z who are accustomed to solving problems using technology through the opportunity to find other sources of information to solve problems (Word, 2013; Geck, 2006). The learning design in the reasoning phase aims to train KBK-KL on indicators of predictive thinking and dealing with label errors

Phase 4. Clarification and Evaluation. This phase strengthens the explanation phase contained in the inquiry model. In addition to the explanation in the form of presentation of the results of the practicum, there are additional activities in the form of discussion of independent assignments and confirmation of knowledge through evaluation. This activity is carried out in order to clarify students' critical thinking skills through guided activities (Diani *et al*., 2020; Herunata *et al*., 2020). Guidance in this phase is guided directly by the lecturer, this will streamline the learning process and objectives (Pratama *et al*., (2020). The activity of delivering arguments and additional critical thinking skills training through questions are expected that students have two experiences in working on questions related to critical thinking skills. So that the number of practice questions students will be more skilled in solving problems related to critical thinking skills (Halpern, 2014: 37; Ennis, 2016).

Learning theory foundation meaningful learning that is associating new information with information of others who have saved memory for a long time (Moreno, 2010; Tomei, 2010; Slavin, 2011). Reinforced by cognitive theory that contains the formation of schemata is carried out through activities discussed together (Arend, 2008). With social interaction, it will spur the development of new ideas and increase intellectual development or the Zone of Proximal Development (ZPD) (Arend, 2008: 105; Slavin, 2011).

Learning activities are carried out face-to-face synchronously using a video conference learning platform (Jung & Richter, 2019; Sewart, 2014). The purpose of this technology is to facilitate students to interact directly (Seemiller & Grace, 2016). Interaction will strengthen learning motivation (Anjana, 2018), and facilitate social factors that are owned by every human individual (Hartnett, 2016). Another technology used is the Learning Management System (LMS) as a medium for sending quiz results, this will streamline the learning process and objectives (Pratama *et al*., (2020). The learning design in the clarification and evaluation phase aims to train KBK-KL on indicators of assessing phenomena based on appropriate concepts and evaluating one's line of thought.

Phase 5. Reflection. This phase is individual in that each student makes a reflection on an action plan, and makes a mind map chart. This phase is supported by the theory of meaningful learning through information organization, namely giving an orderly structure to pieces of information to create visuals of all concepts, for example by making concept maps (Moreno, 2010; Slavin, 2011). It is also supported by metacognition theory which contains strategies for assessing their own understanding by finding out how much time they need to learn something and choosing an effective strategy for learning and or working on problems (Slavin, 2011).

Another technology used is the Learning Management System (LMS) as a medium for sending the results of reflection work on action plans and mind mapping charts, this will streamline the learning process and objectives (Pratama *et al*., (2020). Phase reflection aims to train KBK-KL on indicators of metacognitive thinking.

CLM allowsexistenceassessment and evaluation. Implementation of aassessment to monitor the process of progress and improvement of critical thinking ability on advanced clarification on an ongoing basis. In phase 3 reasoning students do assignments independently and after doing assignments must fill out a difficulty poll in doing assignments independently using the available LMS. The results of filling out the poll will be taken into consideration by lecturers to give special emphasis to indicators of critical thinking ability on advanced clarification which are still considered difficult during phase 4, namely clarification and evaluation. During the evaluation in phase 4, the lecturer also conducted an assessment as a form of confirmation of mastery of critical thinking skills after explanations and emphasis on the concept of advanced clarification components were made.

Very valid on content and construct validity, this shows that there are three things that are fulfilled by CLM, namely there is a need for model development, up-to-date knowledge, and the fulfillment of the components of the learning model. There is a need for model development showing that CLM is developed based on problem identification through preliminary study activities (Plomp & Nieveen, 2013). The findings of the problem are the low critical thinking ability of advanced clarification and the average score of students is in the very less critical category (Figure 1.). The low critical thinking skills further clarified, confirming the results with previous studies (Mundilarto & Ismoyo, 2017; Pradana *et al*., 2017; Herunata *et al*., 2020; Sumarni & Kadarwati, 2020).

The average results of content and construct validity are included in the very valid and reliable category so that substantially the CLM development has met the criteria for model development and model components (Arend 2008; Joyce *et al*., 2009). However, technically there are still suggestions and input by the validator. First, LMS is used as a learning media only, do not use it in the learning process because it will narrow learning activities as a basis for considering areas where internet access is difficult. Second, phase -2 the main focus is not on teamwork but on investigations so that the main goal can be achieved. Third, each figure or table in the CLM academic paper needs to be described in detail. The first and second suggestions do not change the content of CLM development. The researcher has implemented all the suggestions given by the validator.

Based on the analysis of the results of the content validity and construct validity assessments of the three validators, the purpose of this study which reads to produce a valid CLM to improve critical thinking ability on advanced clarification of students in physics courses has been proven true.

2. CLM Device Validity.

a. RPS and (Semester Learning Plan) SAP (Lecture Program Unit)

The measurement of the validity of the content of RPS and SAP includes three aspects, namely completeness of identity, formulation of planned final abilities and components of study materials, learning experiences and learning resources. Based on Table 4.6, the results of the assessment of the validity of the content of RPS and SAP on the aspect of identity have an average score of 3.7, the final planned ability formulation is worth 3.7 and the components of study materials, learning experiences and resources are 3.8. Thus, the average level of scores is between the range (3.5 – 4) so that it can be concluded that the validity of the content of the RPS and SAP is included in the very valid category and does not need revision (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006). The results of the calculation of the percentage of agreement on the identity completeness aspect is 89%, the final planned capability formulation aspect is 86%, component aspects of study materials, learning experiences and learning resources 100%. Thus, the percentage of agreement level exceeds 75% so that it can be concluded that the validity of the content of the RPS and SAP is reliable (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006).

Content validity included in the very valid category means that the RPS and SAP tools have been measured by the validator in terms of completeness of identity, the formulation of the planned final capabilities and components of study materials, learning experiences and resources in accordance with the criteria for developing RPS and PP. While content validity has a reliable category, it means that the three validators in assessing the validity of the content of the RPS, and SAP have consistent results.

The assessment of construct validity includes three aspects, namely presentation in learning, time allocation, and assessment. Based on Table 4.7 the results of the assessment of the construct validity of the RPS and SAP on the presentation aspect in learning have an average score of 4, time allocation has an average score of 3.7, and the assessment has an average score of 3.8. Thus, the average level of scores is between the range (3.5 – 4) so that it can be concluded that construct validity is included in the very valid category and does not need revision (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006). The percentage of agreement on the presentation aspect in learning is 100%, the time allocation aspect is 97%, and the assessment aspect is 100%.

Construct validity is included in the very valid category, meaning that the RPS and SAP structures are made to support the achievement of the CLM model. While construct validity has a reliable category, meaning that the three validators in assessing the construct validity of the RPS and SAP have scores that are not much different or the research results are consistent.

Substantially, the RPS and SAP, both content and construct validity, are very valid and have met the criteria for a good learning planning tool. However, technically there are still suggestions and input for the development of RPS. First, try to keep the bibliography up to date, and second, check the time allocation again.

The first and second suggestions don't change the content. Researchers have revised the RPS and SAP according to suggestions and input from the validator.

Based on the analysis of the results of the content validity and construct validity assessments of the three validators, the hypothesis of this study which reads to produce RPS and SAP CLM to improve critical thinking ability on advanced clarification of students in physics courses has been proven true.

b. BAM (Student Textbook)

Measurement of the validity of the content of BAM includes three aspects, namely aspects of the suitability of the material with learning outcomes, the accuracy of the material, and learning support. Based on Table 4.9, the results of the BAM content validity assessment in the aspect of the suitability of the material with learning outcomes have an average score of 4, the accuracy of the material has a score of 3.6 and the learning support component is 4. Thus, the average level of scores is between the range (3.5 - 4) so that it can be concluded that the content validity is included in the very valid category and there is no need for revision (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006). The results of the calculation of the percentage of agreement of the three validators on the aspect of the suitability of the material with learning achievement of 100%, the accuracy of the material by 86%, aspects of the component supporting learning 100%.

Content validity is included in the very valid category, meaning that the BAM that has been measured by the validator in terms of the suitability of the material with learning outcomes, the accuracy of the material, and the support for learning is in accordance with the material of effort and energy and can help achieve CLM goals. While the content validity has a reliable category, it means that the three validators in assessing the content validity of BAM have results that are not much different or consistent results.

The construct validity measured by the three validators includes three aspects, namely presentation technique, presentation of material, and completeness of presentation. Based on Table 4.10 the results of the BAM construct validity assessment in the presentation technique aspect have an average score of 4, the presentation of the material has an average score of 3.9, and the completeness of the presentation has an average score of 3.6. Thus, the average level of scores is between the range (3.5 – 4) so that it can be concluded that construct validity is included in the very valid category and does not need revision (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006). The percentage of agreement level of the three validators on the technical aspect of presentation is 100%, material presentation is 97%, and presentation completeness is 97%.

Construct validity is included in the very valid category, meaning that the BAM structure is made to support the achievement of the CLM model. While construct validity has a reliable category meaning that the three validators in assessing the construct validity of BAM have consistent results.

Substantially, the BAM design, both content and construct validity, is very valid and has met the established criteria. However, technically there are suggestions and inputs for improving BAM. First, try to keep the bibliography up to date, second, give style diagrams to make the physics concept stronger and reduce image capture from the internet. The first and second suggestions do not change the content. Researchers have revised BAM according to the validator's suggestion.

Based on the analysis of the results of the content validity and construct validity assessments of the three validators, the hypothesis of this study which reads as producing BAM to improve students' KBK-KL in physics courses has been proven true.

B. Practicality

Practicality aims to determine the extent to which the planned CLM design is practical or not when used through limited-scale and wide-scale trials. Practical means that the phases in the CLM syntax are easy to apply in the learning process. Practicality was measured using a CLM implementation observation sheet and a CLM implementation constraint sheet by two observers.

The limited-scale test of the practicality of CLM and its equipment was carried out in one place, namely the Informatics Education Study Program, Trunojoyo University, Madura, for basic physics courses. The number of samples that received the CLM intervention was two classes. Meanwhile, in the large-scale test, CLM and its equipment were tested in three universities, namely Trunojoyo Madura University with 2 classes, namely, one class at Lampung University, and one class at IVET University Semarang.

The results of the limited-scale test are shown in Table 4.13 and the broad-scale test is shown in Table 4.16. The results show that both the learning orientation phase, the investigation phase, the reasoning phase, the clarification and evaluation phase, and the reflection phase have very good categories. This means that CLM achieves the minimum target, namely the good category (Ratumanan & Laurens, 2006). In addition, it reaches the minimum percentage of agreement 75% (Borich, 1994). In addition, notes on learning device problems are only related to typos. Thus, CLM and Practical CLM devices are used. The results of this practicality cannot be separated from the precise provision of solutions to every problem that arises in CLM learning, and the importance of evaluation in each lesson.

First, it is precisely the provision of solutions to learning problems. Note that the obstacles in implementing the CLM small-scale test are network connection problems, time effectiveness in phase 2 of the investigation, and reasoning tasks, students are not confident in expressing the results of doing assignments or quizzes (Table 4.14). The problem of network connection is beyond the ability of the researcher so that the solution given is only in the form of giving PPT which contains material and discussion of each reasoning task and quiz as additional learning material. As Anjana (2018) argues, the provision of services to students in distance learning is a very important factor because they often have obstacles or problems. Likewise, the results of Barry & Kanematsu (2020) every student has different conditions, both influenced by technical and non-technical factors, so educators need to continue to open up to serve them. Because some students still have difficulties in learning (Dew *et al*., 2020).

Less prepared for lectures, and Phase-2 student inquiry and reasoning assignments take longer. Because physics courses are only limited to 2 credits or 100 minutes in one virtual face-to-face, the solution given to improve CLM is optimizing the LMS for pre-learning, namely in addition to providing textbook files, students are given additional experimental videos using Phet Simulation. In addition to simulation videos, reasoning tasks are also provided through LMS so that students can practice before the virtual face-to-face takes place (Table 4.15). Based on the research constraints notes at the 3rd and 4th meetings, there were no more problems related to the lack of time in the investigation and execution of the reasoning task. The availability of a Learning Management System (LMS) can be optimized to provide material content, detect capabilities, measure and organize goals (Hoq, 2020). By sending reasoning assignments, students will be more independent in preparing lecture materials, as Jung & Richter (2019) argue that so that students have the initiative to learn independently in the implementation of distance learning, various guides can be in the form of video tutorials or books equipped with detailed instructions.

The findings of the limited-scale test, the findings of the problem include network connection problems, the first meeting of students who are not used to making explanations with scientific arguments, are not confident inconveyresult of workreasoningand quiz (4.14). At the initial meeting, students have not been able to make arguments to explain the results of the answers, resulting in them not being confident in answering questions. These results confirm the results of pradana research on optical physics students, students only used to implement equations found in physics (Pradana *et al*., 2017). Likewise in high school chemistry lessons, the low KBK-KL is due to them not accustomed to making explanations of an answer (Herawati *et al*., 2020; Herunata *et al*., 2020; Sumarni & Kadarwati, 2020).

The next problem at the initial meeting is that there are difficulties running the Phet Simulation application which resulted in less effective time in phase 2 (Table 4.14). These results confirm the results of the study with the conclusion that online learning is not an easy activity, from the research results, many students have decreased in doing assignments independently (Dew *et al*., 2020; Agormedah *et al*., 2020).During the distance learning pandemic mediated by various information technology platforms, educators need to be prepared to master the technology (Agormedah *et al*., 2020; Mishra *et al*., 2020).The impact of changing face-to-face learning to distance learning has not been able to run optimally (Dew *et al*., 2020; Hidayat & Authority, 2020)

The solution applied is the same, namely providing a PPT file for every virtual face after finishing learning as an independent study material and providing video simulation learning. The solutions provided in reducing the difficulty of learning independently. Learning materials are indispensable in distance learning, as much as possible with detailed instructions (Algeria, 2020). This activity is carried out also by previous researchers who used virtual experiments (Hashemipour *et al*., 2011). Practice Experiment by Virtual reality can reduce fear if something goes wrong (Onal & Onal, 2020).

Not being confident is done with the help of lecturers to students by giving several questions to be able to relate the problem to the given concept. An open and friendly nature during distance learning is an important element in learning long distance. The results of research related to the importance of caring are shown in the research of Reinholz *et al*., (2020) it is concluded that distance learning needs to develop an inclusive curriculum, one of which pays attention to their background, this is shown starting from their life experiences. Barry & Kanematsu (2020) as a teacher should not be too rigid, we must care about the condition of each student and continue to speak openly in providing learning support. Because some students still have difficulties in learning (Dew *et al*., 2020). Even Karakaya *et al*., (2020) in their research results show that the most important thing is to touch the nuances of students' feelings.

Second, the importance of evaluation in learning. Based on Table 4.12, Table 4.13 and Table 4.16 there is an increase in the average value of the implementation of learning and an increase in the level of percentage of agreement. Reinforced by reducing the problems faced every time we meet face to face. In addition, the score of implementations and the level of percentage of agreement in the wide-scale test (Table 4.16) is greater than the small-scale test (Tables 4.12 and 4.13). These results indicate that evaluation can improve the quality of learning. These results confirm research (Khaeruddin, 2017) at the beginning of learning not all FPBKPS syntax can run well, after an evaluation at the fourth meeting all syntax can be implemented properly. Another study found that through the evaluation of the application of the U-seat model, it was still found that it was difficult for students to communicate in electronics courses from one end to another, so that changing face-to-face could improve communication between students (Saputro, 2018). Likewise, the application of the IBSC problem model on a wide-scale test has better results due to the learning evaluation at the end of the meeting with the supervisor (Suharti, 2019).

C. Effectiveness of CLM

MasteryCritical thinking ability on advanced clarification of students in physics courses are indicated by the achievement of the student's answer components. The achievement of components will be categorized as critical thinking skills ranging from very less critical, less critical, quite critical, critical, and very critical (Seruni *et al*., 2020). While the increase in N-Gain critical thinking ability consists of low, medium and high (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006). In addition to mastering critical thinking skills, students' responses to CLM and its tools will also be described, as well as self-confidence in further clarifying thinking skills. The detailed explanation is as follows.

1. The effectiveness of CLM to increase KBK-KL.

ResultsTesting the effectiveness of CLM and learning tools obtained data processing the pre-test and post-test scores of KBK-KL both on a limited scale test and a wide scale test. The pre-test was done by the students before the CLM learning activities, while the post-test after the students received a learning intervention using CLM was precisely in the last session after the fourth meeting. CLM trials and CLM learning tools were carried out specifically for special students in the Vocational Education and Information Technology sub-groups of basic physics courses. The study programs are the Informatics Education Study Program at Trunojoyo Madura University, the Information Technology Education Study Program at the University of Lampung and the Informatics Education Study Program at IVET University, Semarang.

Based on the acquisition of the KBK-KL scores, both the limited and broad scale tests were discussed starting from the KBK-KL pre-test scores and KBK-KL post-test scores. The findings based on these scores are the low pre-test of KBK-KL, the broad scale test has better results than the limited scale, the achievement of each KBK-KL indicator, and the findings of the lowest indicator of KBK-KL. These findings will be discussed by reviewing the findings from observations of the practicality of CLM and student response questionnaires as well as relevant research results.

The first finding was the low KBK-KL pre-test score. These results are shown in Table 4.19, the average pretest score for the PIF B UTM class is 3.29, and the PIF D UTM class is 3.11, thus both classes are included in the very less critical category. Likewise, the results of the broad scale test mean the PIF A UTM class score is 3.67, the PIF C UTM is 3.04, PTI UNILA is 2.68, and the PIF IVET is 3.83. The four classes on the broad-scale test are also included in the very less critical category.

The low pretest scores on the limited and broad scale tests indicate that prior to the learning activities the students were unable to complete the KBK-KL test. These results confirm the results of the preliminary study, students still have difficulty solving questions on the KBK-KL component (Figure 1.1). Likewise, confirming previous research on student survey research in optical subjects, the results showed that the average score on the KBK-KL component of 51.7 was included in the low category (Pradana & Parno, 2017). Likewise, research on the subject of junior high school students in physics lessons on fluid subjects the average score on the KBK-KL component is included in the very low category.

This result is due to being able to master critical thinking skills, special learning designs are needed with various forms of activities, such as analyzing, comparing and other activities (Stephen Johnson; Harvey Siegel, 2010). This opinion is reinforced by McPeck (2017), namely the ability to think critically is a skill, so it can be taught through a certain training. Critical thinkers only provide signs for the pattern of teaching critical thinking skills in general, namely learning can be done through a problem-solving process (Ennis, 2015:44; Facione & Gitten, 2016).

Second findbroad scale test has better results than the limited scale test. After the application of CLM, the results of the KBK-KL post-test on the N-Gain score scale test were included in the medium category (Table 4.18, Figure 4.3 and Figure 4.4). These results indicate that in the limited-scale test the N-Gain KBK-KL score is lower than the broad-scale test. The results were analyzed for each KBK-KL indicator, two indicators included in the high category, namely assessing phenomena based on the right concept, and handling label errors. The other five indicators are in the moderate category, namely evaluating a person's flow of thought, identifying unstated assumptions, predictive thinking, metacognitive thinking, and solving problems in order (Table 4.20). So is the level of critical thinking skills KBK-KL post-test score on a limited scale test included in the category of critical enough (Table 4.19). Reinforced with2 independent sample tests using the Mann-Whitney Test obtained a significance value of 0.712 > 0.05 so it can be concluded that CLM and learning tools have the same effect of increasing the N-Gain KBK-KL in the limited-scale class group (Table 4.24).

Compared with the results of the limited-scale test, the results of the N-Gain score on the broad-scale test are higher, namely the high category (Table 4.18, Figure 4.3 and Figure 4.4). So is the level of critical thinking skillsKBK-KL post-test score on a broad scale test included in the critical category (Table 4.19). The two indicators are included in the very critical category, namely assessing the phenomenon based on the right concept, and handling label errors. The other five indicators are included in the critical category, namely evaluating a person's line of thought, identifying unstated assumptions, predictive thinking, metacognitive thinking, and solving problems in order (Table 4.19). Details of each indicator details Reinforced resultsKruskal Wallis Test obtained a significance value of 0.53 > 0.05, so it can be concluded that CLM and learning tools have the same effect on increasing the N-Gain KBK-KL in the broad-scale class group (Table 4.24).

Research development products in the form of CLM and learning tools were tested both on a limited scale, and on a wide scale test that had reached the minimum target of N-Gain in the medium category (Akhdinirwanto *et al*., 2020; Ratumanan & Laurens, 2006) and the minimum level of critical thinking ability is in the moderately critical category (Pursitasari *et al*., 2020). Thus, both the limited scale test and the product development scale in the form of CLM and learning tools are effective for improving students' KBK-KL in physics courses.

The results of product testing on a limited scale are lower than on a wide scale, this is due to the lack of optimal CLM and learning tools. The total of all

KBK-KL indicators are in the medium category with details of the five KBK-KL indicators the average N-Gain is in the medium category, the level of critical thinking ability is in the moderately critical category (Table 4.18 and Table 4.19). The five KBK-KL indicators include evaluating a person's line of thought, identifying unstated assumptions, predictive thinking, metacognitive thinking and solving problems sequentially (Table 4.20). The two KBK-KL indicators on average N-Gain are included in the high category, the level of critical thinking ability is in the very critical category. The two indicators are assessing the phenomenon based on the right concept, and dealing with label errors (Table 4.20).

The cause of the CLM and CLM devices not being optimal in learning is shown in the data on the results of the practicality of CLM. The results of observations by observers, both CLM and equipment, there are still many obstacles in the implementation process (Table 4.14). These data indicate that in the limited-scale test at meeting 1 there is a problem regarding the suitability of time, it needs attention because in the introduction it takes quite a long time. Network connection problems are still a problem, so students cannot display the video. The group discussion process did not run smoothly. Students are not ready to attend lectures.

CLM is not optimal at meeting 2, namely there are students who find it difficult to enter via the zoom meeting and students lack time to complete investigations and reasoning tasks. Technical problems began to run smoothly starting from the 3rd and 4th meetings. The material curriculum is hierarchical, meaning that the concepts that have been studied will strengthen the next concept. However, at meeting 1 and meeting 2 there were technical problems related to time management. While in the learning device there are still errors in making conclusions in the discussion of the reasoning task. There are spelling errors such as arrows, comparisons and use of spaces.

Time management constraints caused by network signal constraints. Not all students are in a strong network signal, the existence of a break out room causes the entry and exit process in the Zoom Meeting to take longer. Because distance learning is always mediated by various information technology platforms, it requires the readiness of educators and students to master the technology (Agormedah *et al*., 2020; Mishra *et al*., 2020). Even network access is a critical success factor for distance learning (Hidayat & Wibawa 2020). New habits in distance learning also affect student adaptation in the learning process. Experimental distance learning who are accustomed to real conditions turn into simulated through experiments virtually (Hashemi Pour *et al*., 2011)

The lack of time for students in doing reasoning tasks was still found in meetings one and two. This is because students are still not used to solving reasoning problems individually. These results confirm previous research that students are still not used to answering questions by making a rational argument (Pradana *et al*., 2017). Students still find it difficult to connect the concept with the problem at hand (Sumarni & Kadarwati, 2020). This problem is also caused by each student having different initial abilities (Awan *et al*., 2017; Herawati *et al*., 2020). In a psychological study of the effectiveness of learning models, the development of learning models needs to pay attention to differences in levels of academic ability (Slavin, 2011).

The next problem is the discussion process does not run smoothly. The lack of optimal discussion has an impact on the not yet optimal theory of social constructivism in learning. Vygotsky said that the Zone of Proximal Development (ZPD) is very important in learning. The main emphasis in this theory lies in the importance of social and cultural interactions in learning (Moreno, 2010). This is reinforced byHartnett, (2016) states that the interaction between educators and students aims for students to gain knowledge, build meaning and have learning experiences. Pratama *et al*., (2020) concluded that the existence of learning facilities both face-to-face and online was able to facilitate interaction and be effective towards learning objectives. Discussion is very important because Generation Z learning wants learning that is based on logic and existence experience, so it can be used for problem solving (Seemiller & Grace, 2016).

The results of the CLM test and the CLM device on a wide scale are better than on a limited scale. As shown in Table 4.18 and Figure 4.3, it can be seen that there is an increase in N-Gain in the wide-scale test. The total research data for all KBK-KL indicators on average N-Gain is in the high category and the level of critical thinking ability is included in the critical category (Table 4.18 and Table 4.19). The seven indicators include assessing phenomena based on appropriate concepts, evaluating a person's line of thought, identifying unstated assumptions, predictive thinking, handling label errors, metacognitive thinking and solving problems sequentially (Table 4.20).

This result is supported by the four classes in the wide-scale test, all classes are included in the very good category with the percentage of agreement between the two validators being able to reach 99% and 100% (Table 4.16). In line with the results of observations by the observer, namely the results of student responses to CLM in the wide-scale test the average of the four classes has a percentage level of 91% (Figure 4.9). These results mean that students strongly agree that CLM learning can improve KBK-KL. Other supporting data are the results of student responses to CLM learning tools, namely: BAM with average the percentage in the four classes reached 91%, meaning that students agree that BAM supports students to be able to help CLM in improving KBK-KL.

Optimal research products, namely CLM and learning tools, are supported by the results of the practicality of CLM based on observations of obstacles by observers which show low barriers to CLM implementation (Table 4.17). These results were obtained because the researchers had made improvements to the CLM as listed in Table 4.15. First, there is an optimization of LMS for pre-learning. In addition to giving textbooks, students need to be given practical simulation videos using Phet Simulation, and reasoning tasks so that students can practice before the virtual face-to-face takes place. The activities of providing textbooks, video simulations are part of the learning scaffolding (Capaldi, 2015). The provision of teaching materials and video tutorials can foster independent learning (Jung & Richter 2019). Reinforcing the results of research on the material organic chemistry researchers design learning apart from meetings by online, lecturers also provide material and assignments in the form of documents in the form of files or videos on*Facebook* activity it makes students learn independently (Danjou, 2020). Barry & Kanematsu (2020) as a teacher should not be too rigid, we must care about the condition of each student and continue to speak openly in providing learning support. Because some students still have difficulties in learning (Dew *et al*., 2020).

Continue to confirm understanding to students. Lecturers need to open up and often ask how they understand the explanations that have been made by the lecturer. Optimization to be open to students is done because students often experience obstacles in learning remotely (Anjana 2018). Learners need services to support communication as needed (Bork & Gunnarsdottir, 2001). Reinholz *et al*., (2020) emphasize that distance learning needs to develop an inclusive curriculum, one of which pays attention to their background, this is shown starting from their life experiences. Even Karakaya *et al*., (2020) distance learning even though the material standards have been set, the most important thing is to touch the nuances of the students' feelings. ask news,

It is important to be responsive to students to communicate with generation Z. The results of Yu's research (2016) state that the communication character of generation Z students is caring, namely caring about the lives of others and respect for people who care about them so that it has a high impact on solidarity. In addition, it shows an open attitude to anyone, and wants interaction in a communication pattern or not one-way communication, which is ready to accept all ideas and want to be heard every time (Seemiller & Grace, 2016:26-27; Fernández & Fernández, 2016). Thus, students want an interactive pattern of communication, and they want an element of communication concerning each other in life.

Strengtheningmaterial, for material that is important the lecturer needs to confirm the material through speech that is repeated twice or convey this is the key word of the material. This activity strengthens the theory of meaningful learning, which is an activity carried out through expanding the original information by associating new information with other information stored in long-term memory (Moreno, 2010:203; Slavin, 2011:250). The method used is the elaboration method, where students use previous knowledge to expand a new idea. While the organization provides an orderly structure on pieces of information to create visuals of all concepts, for example by making concept maps. As research resultsPrayogi & Verawati, (2020) with the conclusion that making concept maps improves critical thinking skills. Making certain products in learning can improve learning outcomes (Saputro *et al*., 2014)

Based on the evaluation of the application of CLM on a wide-scale test (Table 4.17) the problem of lack of learning time is no longer found, it is more of a technical network problem and students are not confident in expressing ideas and ideas. These problems were overcome by strengthening students' motivation to dare to present the results of their work. Strengthening assistance in making arguments to increase students' courage to dare to convey the results of working on questions. Optimizing practice and guidance in working on thinking tests (Diani *et al*., 2020; Herunata *et al*., 2020).

Giving appreciation to students who actively convey the results of their work. Giving appreciation to generation Z. studentsHe naturally likes to be cared for by others who showed through communication (Miller, 2019). Appreciation can provide a comfortable and friendly atmosphere in the learning process. According to Jung & Richter (2019), distance learning also needs to pay attention to the differences in the backgrounds of the students, both cultural and socio-economic. Likewise, Bork & Gunnarsdottir (2001:104) argue that being a teacher must have a friendly and non-judgmental attitude to be able to provide assistance when there are problems in mastering the material and continue to provide motivation. Even Karakaya *et al*., (2020) distance learning even though the material standards have been set, the most important thing is to touch the nuances of the students' feelings. Asking news, caring gives a close feel to move their motivation, this can encourage motivation to stay in distance learning.

Third, finding the achievement of CLM and learning tools can achieve the target of each KBK-KL indicator. This result proved that the N-Gain score was included in the high category and the KBK-KL level was included in the critical category (Table 4.18 and Table 4.19). Two KBK-KL indicators can be maximized, namely assessing phenomena using the right concept and handling label errors, namely the N-Gain category is very high and the KBK-KL level is included in the very critical category (Table 4.20 and Table 4.21). However, five indicators were identified to evaluate a person's line of thought, predictive thinking, identify unstated assumptions, metacognitive thinking, and solve problems sequentially, which are included in the critical category (Table 4.21). This result is supported by the optimal practicality of CLM in the data from the implementation of CLM where all phases are included in the very good category with the percentage of agreement in the four classes between 99% to 100%. Reinforced by the results of student questionnaire scores which show that each phase of CLM is responded very strongly by students with a percentage ranging from 87% to 95% (Figure 4.9)

The first phase of learning orientation aims to train KBK-KL indicators of metacognitive thinking. The facts of the research results obtained that the average N-Gain score of 0.744 was included in the high category and the level of critical thinking ability was included in the critical category (Tables 4.20 and 4.21). Thus, the design of the learning orientation phase is effective to improve the KBK-KL on indicators of metacognitive ability. This result is supported by the results of the implementation of CLM which has a very good category with the percentage of agreement included in the reliable category (Table 4.16). These results are in line with the results of student responses to the learning orientation phase which was responded very strongly by students with an average percentage of 91% (Figure 4.9).

The success of the design in the orientation phase cannot be separated from the strong support from learning theory and empirical research evidence. In this phase, the activities carried out by students focus on the facts presented by the lecturer and argue according to the knowledge from experience that each student has. This activity strengthens the problem presentation phase in the inquiry model (Arend, 2008:31). This phase was chosen based on previous research suggestions which stated that through presenting authentic problems it could provide a stimulus for critical thinking skills (Mundilarto & Ismoyo, 2017; Kadarwati 2020; Rahmi *et al*., 2019; Diani *et al*., 2020). The right step for students to construct knowledge is through an event(Ray, 2002; Chang, 2005).In cognitive theory, each given phenomenon will be responded to through organizing the knowledge that has been possessed (schemata) which is called assimilation (Arend, 2008: 34; Moreno, 2010:

79).Providing information on the purpose of problem solving to achieve certain learning objectives, so that in order to be maximal in achieving student goals, students make lesson plans implementing metacognitive theory(Moreno, 2010:227).

Activity Learning is carried out face-to-face synchronously, facilitated by technology using a video conference learning platform, which is the main characteristic of distance learning (Jung & Richter, 2019:1; Sewart, 2014).The purpose of this technology is to facilitate students to interact directly (Seemiller & Grace, 2016:59). Interaction will strengthen an important factor in distance learning, namely learning motivation (Anjana, 2018:16), and facilitating social factors that are owned by each individual human being (Hartnett, 2016:2). Another technology used is the Learning Management System (LMS) as a medium for sending learning resources such as textbooks, Phet Simulation programs, sending action plan sheets, this will streamline the learning process and objectives (Pratama *et al.*, 2020).

The learning objectives are related to the benefits that will be obtained for the field of informatics; this is because generation Z students are very realistic in thinking (Seemiller & Grace, 2016). Students want to apply the theory they already have to solve problems in the world of work (Purcell & Purcell, 2019). So that it will foster motivation and interest in learning for each student (Hidayat & Wibawa, 2020).

The first phase of learning orientation aims to train KBK-KL indicators of metacognitive thinking. The research data obtained the average N-Gain score of

0.744 which was included in the high category and the level of critical thinking ability was included in the critical category (Tables 4.20 and 4.21). Thus, the design of the learning orientation phase is effective to improve the KBK-KL on indicators of metacognitive ability.

The second phase of the investigation aims to train KBK-KL indicators to identify unstated assumptions and solve problems in order. The research data obtained the average score of the N-Gain indicator identifying assumptions that were not stated at 0.766 including in the high category and the level of critical thinking skills included in the critical category (Tables 4.20 and 4.21). The average score of the N-Gain indicator for solving problems sequentially is 0.765 which is included in the high category and the level of critical thinking ability is included in the critical category (Tables 4.18 and 4.19). Thus, the design of the learning orientation phase is effective for improving the KBK-KL indicators, identifying unstated assumptions and solving problems sequentially. This result is supported by the results of the implementation of CLM which has a very good category with the percentage of agreement included in the reliable category (Table 4.16). These results are in line with the results of student responses to the investigation phase which were responded very strongly by students with an average percentage of 88% (Figure 4.9).

The success of the design in the investigation phase cannot be separated from the strong support of learning theory and empirical research evidence. In this phase, the activities carried out by students in groups are formulating hypotheses, conducting experiments, processing data and making conclusions. This activity combines the phases of data verification, hypothesis, data collection and explanation of the inquiry model (Arend, 2008). This phase is the implementation of the essence of critical thinking skills: process thinking rationally with appropriate explanations based on evidence (Ennis, 1985a; Halpern, 1999; McPeck, 1981; Siegel, 1991). This activity is also based on research suggestions which contain that it is necessary to hypothesize and prove hypotheses to build one's critical thinking skills (Mundilarto & Ismoyo, 2017; Kadarwati 2020; Rahmi *et al.*, 2019; Diani *et al.*, 2020).

In theory of learning, the process of inquiry can optimize one's cognitive participation such as analysis, interpretation, inference and sharing activities number construct knowledge (Chang, 2005). Investigation is a cognitive process that builds knowledge through matching new data or situations to existing schemata to develop new concepts or schemata called accommodation (Arend, 2008; Moreno, 2010). It is the basis of discovery learning theory, namely the concept is not the result of giving but needs to be discovered by students (Moreno, 2010). The emphasis on learning needs to emphasize inductive reasoning and the process of inquiry (Arend, 2008; Slavin, 2011). Activities that involve the five senses, thinking and actively conducting experiments will be able to form students' knowledge independently (Arend, 2012). Group activities are the application of social constructivist theory of the application of scaffolding in learning (Moreno, 2010: 88.

Practical activities in groups facilitate generationZ in being an open person through interactions in interactive communication patterns (Seemiller & Grace, 2016: 26-27; Fernández & Fernández, 2016). Besides that group activities will optimize the involvement of students students in activities learning so that the learning objectives can be effective (Barber, 2020).Discussion activities are the character of adult learners because knowledge is acceptable based on reasons and evidence (Upton & Trapp, 2010:68; Slavin, 2011:54).

The third phase of reasoning aims to train the KBK-KL indicators of predictive thinking and dealing with label errors. The research data obtained the average score of N-Gain predictive thinking indicator of 0.774 which was included in the high category and the level of critical thinking ability was included in the critical category (Tables 4.20 and 4.21). The average score of the N-Gain indicator for handling label errors is 0.932 which is included in the high category and the level of critical thinking ability is included in the very critical category (Tables 4.18 and 4.19). Thus, the design of the learning orientation phase is effective for improving the KBK-KL indicators of predictive thinking indicators and dealing with label errors. This result is supported by the results of the implementation of CLM which has a very good category with the percentage of agreement included in the reliable category (Table 4.16).

The success of the design in the reasoning phase cannot be separated from the strong support of learning theory and empirical research evidence. In this phase, students do activities independently to analyze a problem. Activity This is the implementation of research suggestions that contain the need for guided exercises (Diani *et al*., 2020; Herunata *et al*., 2020). Guidance in this phase is in the form of a textbook guide that is structured with a certain structure to clarify the study material (Bork & Gunnarsdottir, 2001:165; Aljanazrah, 2020). This activity is expected to be able to minimize the non-optimal critical thinking ability on advanced clarification caused by the low reasoning abilities of learners (Pradana & Parno, 2017; Sumarni & Kadarwati, 2020; Herunata *et al*., 2020; and Herawati *et al*., 2020). Low initial ability as the basis of reasoning (Herunata *et al*., 2020),will be minimized through elaboration of tasks that are guided in student textbooks aimed at strengthening the knowledge that has been obtained(Moreno, 2010; Slavin, 2011).

Next Weak Linking the problems encountered with the use of appropriate concepts (Sumarni & Kadarwati, 2020), will be minimized through textbook instructions to find the right concept in solving problems(Saputro, Arifin, *et al*., 2020; Roberson & Franchini, 2014; and Wang *et al*., 2019). The low ability to describe concepts (Pradana & Parno, 2017; Sumarni & Kadarwati, 2020; Herunata *et al*., 2020; and Herawati *et al*., 2020) will be facilitated in textbooks through written language representation activities (Herawati *et al*., 2020).

Learning theory foundation meaningful learning that is associating new information with information of others who saved memory for a long time (Moreno, 2010; Tomei, 2010; Slavin, 2011). Reinforced by cognitive theory that contains the formation of new schemata through asking questions, and making efforts to find answers matching what they have found with their predictions, comparing their findings with the findings of other friends (Arend, 2008). When completing tasks independently, students actively carry out the reasoning process to re-conceptualize the knowledge gained through experimentation, which is the application of cognitive constructivist theory (Aunurahman, 2009).

The technology used is the Learning Management System (LMS) as a medium for sending independent assignments to streamline learning objectives (Pratama *et al*., (2020). In addition, it is a tool for detecting abilities and measuring abilities possessed by students.so that it can be used for determining learning policies (Hoq, 2020). Also pay attention to the habits of Generation Z who are accustomed to solving problems using technology through the opportunity to find other sources of information to solve problems (Wood, 2013; Geck, 2006).

The fourth phase is clarification and evaluation aimed at training KBK-KL indicators to assess phenomena based on appropriate concepts and evaluate a person's line of thought. The research data obtained the average score of the N-Gain indicator assessing phenomena based on the right concept of 0.985 which was included in the high category and the level of critical thinking ability was included in the very critical category (Table 4.20 and Table 4.21). The average score of the N-Gain indicator evaluating a person's flow of thought is 0.829 which is included in the high category and the level of critical thinking ability is included in the very critical category (Table 4.20 and Table 4.21). Thus, the design of the learning orientation phase is effective for improving the KBK-KL indicators, assessing phenomena based on appropriate concepts and evaluating one's line of thought. This result is supported by the results of the implementation of CLM which has a very good category with the percentage of agreement included in the reliable category (Table 4.16). These results are in line with the results of student responses to lecturer guidance and giving quizzes which were responded very strongly by students with an average percentage of 95% (Figure 4.9).

The success of the design in the clarification and evaluation phase cannot be separated from the strong support from learning theory and empirical research evidence. In this phase, students are given the opportunity to take quizzes and ask questions related to the material that has been discussed. This phase strengthens the explanation phase contained in the inquiry model. In addition to the explanation in the form of presentation of the results of the practicum, there are additional activities in the form of discussion of independent assignments and confirmation of knowledge through evaluation. This activity is carried out in order to classify students' critical thinking skills through guided activities (Diani *et al*., 2020; Herunata *et al*., 2020). Guidance in this phase is guided directly by the lecturer, this will streamline the learning process and objectives (Pratama *et al*., (2020). The activity of delivering arguments and additional critical thinking skills training through questions are expected that students have two experiences in working on questions related to critical thinking skills. So that the number of practice questions students will be more skilled in solving problems related to critical thinking skills (Halpern, 2014; Ennis, 2016).

Learning theory foundation meaningful learning that is associating new information with information of others who have saved memory for a long time (Moreno, 2010; Tomei, 2010; Slavin, 2011). Reinforced by cognitive theory that contains the formation of schemata is carried out through activities discussed together (Arend, 2008). With social interaction, it will spur the development of new ideas and increase intellectual development or the Zone of Proximal Development (ZPD) (Arend, 2008; Slavin, 2011).

Learning activities are carried out face-to-face synchronously using a video conference learning platform (Jung & Richter, 2019; Sewart, 2014). The purpose of this technology is to facilitate students to interact directly (Seemiller & Grace, 2016:59). Interaction will strengthen learning motivation (Anjana, 2018), and facilitate social factors that are owned by every human individual (Hartnett, 2016). Another technology used is the Learning Management System (LMS) as a medium for sending quiz results, this will streamline the learning process and objectives (Pratama *et al*., (2020)

Phase Fifth That is reflection aims to train KBK-KL indicators to identify unstated assumptions and solve problems in order. The research data obtained the average score of the N-Gain indicator identifying assumptions that were not stated at 0.766 including in the high category and the level of critical thinking skills included in the critical category (Tables 4.20 and 4.21). Thus, the design of the learning orientation phase is effective to improve the KBK-KL indicators of metacognitive thinking. This result is supported by the results of the implementation of CLM which has a very good category with the percentage of agreement included in the reliable category (Table 4.16). These results are in line with the results of student responses to the reflection phase which were responded very strongly by students with an average percentage of 93% (Figure 4.9).

The success of the design in the reflection phase cannot be separated from the strong support of learning theory and empirical research evidence. In this phase, learning activities students form a summary in the form of a mind map chart. This phase is supported by the theory of meaningful learning through information organization, namely giving an orderly structure to pieces of information to create visuals of all concepts, for example by making concept maps (Moreno, 2010; Slavin, 2011). It is also supported by metacognition theory which contains strategies for assessing their own understanding by finding out how much time they need to learn something and choosing an effective strategy for learning and or working on problems (Slavin, 2011).

Another technology used is the Learning Management System (LMS) as a medium for sending the results of reflection on action plans and mind mapping charts, this will streamline the learning process and objectives (Pratama *et al*., 2020). This activity is a means to increase the meaning of learning through organizing information structures (Moreno, 2010). Charting assignment processmind advanced map and chart organizer can improve critical thinking skills and learning achievement (Prayogi & Verawati, 2020; Saputro *et al*., 2014).

Fourth find the lowest indicator KBK-KL. Among the seven KBK-KL indicators on the broad-scale test the lowest is the ability to solve problems in sequence (Table 4.20). The ability to solve problems sequentially is trained in the CLM syntax in phase-2, namely investigation. The low in this indicator is linear with the implementation of learning in phase-2 which has the lowest score among the five phases in the CLM syntax with a mean score of 3.5 (Table 4.16). This result is also supported by the student response questionnaire in the investigation phase, which is a phase that includes a low score with a mean total percentage of 88% (Figure 4.9).

The investigative activities in phase 2 have actually been facilitated by an investigation video tutorial. However, activities in this phase are carried out in groups, so the lecturers are not fully involved in the investigation process carried out by students. Based on the research constraints on practicality points, as shown in Table 4.17, it was found that at the fourth meeting some groups of students experienced problems operating Phet Simulation Interactive. The factor that causes some laptops to still have low RAM so that it hampers the operating results of Phet Simulation Interactive.

So that students' critical thinking skills can be optimized, LMS can be designed as an optimization of students' initial knowledge. As The results of survey research there is a positive correlation between initial ability and one's critical thinking ability (Awan *et al*., 2017; Herunata *et al*., 2020; Pradana *et al*., 2017). There is a quiz feature, sharing discussion material on this can optimize before the lecture to prepare students' prior knowledge. In addition, independent study assignments can facilitate for students who have different speeds of understanding (Aljanazrah, 2020; Officer & Bezalel, 2008). Learning media such as laptops also need to be considered in order to reduce technical obstacles in operating Phet Simulation Interactive.

2. Student Response

Analysis of student responses to research products, namely CLM and learning tools, is divided into three parts, namely student textbooks, CLM learning and student self-confidence in KBK-KL. Response questionnaires were given during a limited-scale product test, namely PIF B UTM and PIF D UTM and a broad-scale product test, namely in the PIF A UTM, PIF C UTM, PTI UNILA and PIF IVET classes. Categorization of student responses consists of very weak, weak, moderate, strong, and very strong (Riduwan, 2010).The results of the calculation of student response questionnaires, CLM and learning tools can be effective if at least in the strong category, namely the score range (60%-80%).

The results of the calculation of the total average component of both textbooks which include aspects of language, selection of images or graphics, use of sample questions, and features, the results show that all classes are in a very strong category. The lowest percentage is in the aspect of image and feature selection, which is 90% and the highest percentage is in the language aspect (Figure 4.8). The results obtained are able to exceed the minimum limit of effectiveness (60%-80%), so that student textbooks are effective to be used as learning tools to support CLM to improve KBK-KL.

These results indicate that learning independence in distance learning can be done by students if learning resources are available. Online learning during a pandemic is an additional learning space, so students need to optimize learning (Ali 2020). Researchers design learning apart from meetingsbyonline, lecturers also provide material and assignments in the form of documents in the form of files or videos on*Facebook*. Giving materials and assignments is liked by students because they can learn and do assignments at their own pace (Aljanazrah, 2020). Reinforced opinionBork & Gunnarsdottir (2001) that all activities and interactions in learning distance far needs to be developed a module that contains multimedia interactive.

The results of the calculation of the total average of the CLM learning components which include aspects of giving authentic problems, investigations, reasoning tasks, lecturer guidance and giving quizzes, and reflections show that all classes are in the very strong category. The lowest percentage in the aspect of reasoning is 87% and the highest percentage is in the guidance of lecturers and giving quizzes by 95% (Figure 4.9). The results obtained are able to exceed the minimum limit of effectiveness (60%-80%), so it can be concluded that CLM learning is effective for improving KBK-KL.

The reasoning phase has the lowest response because students have to complete assignments independently before being given the material by the lecturer. These results confirm the results of the studyMany students experience a decline in doing assignments independently (Dew *et al*., 2020; Agormedah *et al*., 2020). During the distance learning pandemic mediated by various information technology platforms, educators need to be prepared to master the technology(Agormedah *et al*., 2020; Mishra *et al*., 2020).The impact of changing face-to-face learning to distance learning has not been able to run optimally(Dew *et al*., 2020; Hidayat & Wibawa, 2020).

The low reasoning phase is reinforced by the fact that at meetings one and two they still have difficulty answering reasoning questions. These results confirm previous research that students are still not used to answering questions by making a rational argument (Pradana *et al*., 2017). Students still find it difficult to connect the concept with the problem at hand (Sumarni & Kadarwati, 2020).

The guidance and quiz phases were responded very positively. This confirms the character of the student, distance learning studies. The existence of guidance is a social interaction. Adult learners tend to like to socialize and cooperate and are sensitive tocharacteristicshis group (Garry *et al*., 2013). Slavin, (2011) also said that adults have good friendships, respectselfhigh and social needs. Tomei, (2010) reveals the theory developed byEriksonconcluded that social interaction between students and society is the need of every individual, and has an impact on development of cognitive adult learners. Harris & Cullen, (2010) design an education in order to run well it is necessary to pay attention to the picture of a human life.

Digital technology is indeed the main characteristic of Gen Z, but they also still want an authentic relationship with other people (Seemiller & Grace, 2016). Generation Z is more communication active to care about others (Barreiro & Bozutti, 2017). Interaction in online learning can be asynchronous, namely through discussion forums available on information technology platforms, or synchronously, namely during video conference activities, or streaming. (Skylar, 2009). Application of both synchronous and asynchronous methods is ideal because each student has a different learning speed (Offir & Bezalel, 2008). Thus, the role of interaction in distance learning should be prioritized to maintain the quality of learning. Educators need to open up to students if they experience difficulties while learning.

Related researchoptimizationInformation technology, based on the results of distance learning research through online face-to-face activities, is able to maintain the quality of learning and social interaction (Danjou, 2020). This is reinforced by the research of Pratama *et al*., (2020) concluded that the existence of learning facilities both face-to-face and online was able to facilitate interaction and be effective towards learning objectives. Way of communication by *synchronous liked* by the trainees handling injury bone (Rodrigues *et al*., 2020). In virtual face-to-face learning, it is necessary to present social nuances, namely by mentioning the names of students, and cognitive presence through polling techniques or quizzes are like cutting content to keep students focused in class (Reinholz *et al*., 2020).

The results of the calculation of the average total component of students' self-confidence towards the KBK-KL which includes aspects of the ability to relate problems to the right concept, reasoning ability, and ability to make explanations show that the whole class is in a very strong category. The lowest percentage in the reasoning aspect of 79% is included in the strong response and the highest percentage is in the aspect of relating the problem to the concept and making explanations of 87% included in the strong response category (Figure 4.10). The results obtained are able to exceed the minimum limit of effectiveness (60%-80%), so it can be concluded that CLM learning and its supporting tools are effective in increasing students' self-confidence on KBK-KL.

D. Research Findings

All research findings related to the validity, practicality and effectiveness of CLM are described as follows:

1. CLM and learning tools in the form of RPS, SAP, BAM are proven valid to improve critical thinking skills and clarify continued students on Basic Physics.
   a. CLM proved valid. CLM meets aspected validity, experts agree that CLM is included in content because it is designed according to needs, knowledge up-to-date, and fulfill the components of the learning model. Constructively, CLM has consistency between model components and consistencyAmongmodel with supporting theory. CLM meets actual validity on a limited-scale test and a wide-scale test has been proven to improve critical thinking skills to reach a predetermined standard.
   b. CLM tools include RPS, SAP student textbooks are included in the valid category, so that they meet aspected validity in terms of content, experts agree that CLM tools are in accordance with the correct rules so that they can be used as CLM supporters in improving critical thinking ability on advanced clarification.

      Constructively the CLM tool has consistency with CLM. It means phase learning which is on SAPisThe CLM syntax consists of five phases. All Features in BAM conform to CLM.
2. CLM is proven to be practical to use in learning that aims to improve critical thinking ability on advanced clarification based on findings under this.

a. CLM meets the expected practicality, because the lecturers are ableimplementCLM on both limited-scale and wide-scale tests
b. CLM includes actual practicality, because the limited scale test and broad scale test obtained very good results.

3. CLM is proven to effectively improve critical thinking ability on advanced clarification of students in physics courses based on the cheapest below this.
   a. CLM meets expectations effectiveness based on the results of the expert validation assessment with a few revisions that have been made.
   b. CLM meets actual effectiveness, application to test scale limited critical thinking skills classification can further increase in the moderate category. Test Scale The extent of critical thinking ability on advanced clarification is able to increase in the high category.
   c. Two indicators of critical thinking ability on advanced clarification that are maximally successful are evaluating statements based on appropriate concepts and dealing with error labels of these two indicators students are able to reach the very critical category and the majority of students can reach component 5.
   d. Five indicators of critical thinking ability for advanced clarification have the opportunity to be improved including evaluating the flow of thought, identifying unstated assumptions, predictive thinking, metacognitive thinking, and complete problem in order. These five indicators in the posttest only reached the critical criteria. This result is because the majority of

students cannot fulfill component 6, namely mathematical calculations that use units that should be used.

e. The lowest indicator iscompleteThe problem with this sequence of results cannot be separated from the not yet optimal phase-2 investigation of the CLM syntax. The contributing factor is that some groups of students are still not optimal in operating Phet Interactive Simulations due to incompatible laptops.

CHAPTER VI

CLOSING

A. Conclusion

The conclusion of this research is the Clarity Learning Model (CLM) which was developed to be valid, practical, and effective so that it is suitable for use as learning to improve students' critical thinking ability on advanced clarification. The conclusion above is based on the findings below.

1. The CLM that has been developed is both content and construct valid. The tools developed include RPS, SAP, valid textbooks by content and construct as CLM.
2. The CLM that has been developed is practical, because the COM components can be used heldon a limited-scale trial, and a wide-scale trial well, and without there are significant obstacles.
3. The CLM that has been developed is effective, because: (a) capacity building think critical advanced clarification on the limited scale test in the medium criteria and in the wide trial in the high criteria as well, and CLM gave the same effect significantly; (b) students gave a very strong response to the CLM tools and CLM learning tools that have been carried out.

B. Suggestion

Based on the findings of research results in limited trials and broad trials, some suggestions are given below.

1. The importance of learning independence orientation in the implementation of distance learning. Things that can be done to support independent learning through the provision of teaching materials complete with instructions clear and easy to understand.
2. The importance of optimizing learning scaffolding. In independent study, students still find it difficult to understand the available texts, one of which is that the lecturer needs to make videos practical simulation using Phet Interactive Simulations.
3. Optimization Participatory approach to learning. Lecturers need to make mutual agreements regarding assignments, learning mechanisms so that learning objectives can run optimally.
4. At the end of the lesson the importance of optimizing the meaning of learning. Material keywords, important points need elaborated through rewriting activities with a summary of the mind map chart or other summary methods.
5. The need for compatible media so that learning activities to construct student knowledge can run optimally.

C. Implications of Research Results

1. For Indonesian Education

a. CLM is designed to enhance capabilities through advanced critical clarification in solving real-life problems and practicing the ability to make explanations or arguments. LPTKs can use it to print the competence of graduates who are able to solve problems in overcoming the various impacts of the development of science and technology.

b. CLM is proven valid, practical, and effective for improving the ability to think critically advanced clarification. CLM deserves to be used as an alternative model to overcome the quality problems of LPTKs in Indonesia.

2. For Further Researchers

a. Five indicators of critical thinking ability for advanced clarification have the opportunity to be improved including evaluating the flow of thought, identifying unstated assumptions, predictive thinking, metacognitive thinking, and complete problem in order. These five indicators in the posttest only reached the critical criteria. This result is because the majority of students cannot fulfill component 6, namely mathematical calculations that use units that should be used. Future learning needs to pay attention to quantities and units when describing the results of working on questions.

b. Students still need to be appointed to submit the results of assignments and quizzes. In the future, apart from training critical thinking skills, it is necessary to strengthen self-confidence in their abilities.

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