# Framework for critical thinking skills as a preservice physics teacher competence

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**Abstract**
Critical thinking skills (CTS) are among the 21st-century skills needed. Preservice physics teachers need CTS to solve problems critically, not only in academics but also in life. This research offers a comprehensive perspective and understanding of critical thinking skills as a framework for measuring the ability of preservice physics teachers. The approach is qualitative with methodology analysis, and the documentary content produces a theoretical competence framework. Findings are then applied to determine CTS indicators' relevant competencies, such as clarity assumption, interpretation, analysis, reason, and evaluation. Preservice physics teachers can understand and use these results to evaluate CTS. The research emphasizes optimizing CTS for preservice physics teachers because education is increasingly complex and dynamic

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## 1. Introduction

CT is viewed as a fundamental competence for students to learn and become more professional in the future and is considered a skill in the 21st century (Madden & Dedic, 2022; Payan-Carreira et al., 2022). CT is necessary in real-world scenarios where individuals must navigate developing information fast and make the right decision. It helps to organize and process information meaningfully, which is very important for breaking down effective problems in various contexts, professional and personal (Bueno & Rodas, 2025; Dwyer et al., 2014; Gibson, 2016; Sharma et al., 2022).

CTS involves active and skilled perception, analysis, synthesis, and evaluation of information collected through observation, experience, and communication, leading to informed decisions and actions (Abasaid & Ferreira, 2022; Marcum, 2017; Papathanasiou et al., 2014). CTS is a metacognitive process through purposeful and reflective assessment, enhancing the possibility of logically producing a conclusion or solution for problems (Dwyer et al., 2014; Marthaliakirana et al., 2022; Rivas et al., 2022). CTS is essential for breaking down problems, making decisions, and adapting to new information and situations.

Building CTS in institutional education height is very important For developing holistic and decision-making decisions and breaking successful problems (Saikia & Roy, 2024). Development of CTS can be achieved through purposeful and reflective assessment, as well as arrangement of self, which leads to the conclusion of logical and appropriate action (Payan-Carreira et al., 2022). Evaluation CTS needs valid and reliable instruments (Bhakti et al., 2023; Marfu'i, 2019; Rabu et al., 2016; Sutarno et al., 2019). CTS is important for educational achievement and the development of professional sustainability.

Critical thinking (CT) involves solving problems logically and reflectively in an independent process of solving issues for somebody through metacognitive activity (Gotoh, 2015). CT consists in reflecting on decisions, what should be trusted or done, and skill components. The main thing covers clarifying meaning, analyzing an argument, evaluating evidence, assessing conclusions, and interesting reasoned conclusions (Hitchcock, 2017). CT involves multifaceted skills, including clarifying meaning, argument analysis, evidence evaluation, and reasoned judgment creation (Gibson, 2016; Lovegreen, 2020; Rivas et al., 2022). CT involves the operation of cognitive levels like interpretation, analysis, evaluation, inference, explanation, and arrangement of self (Gibson, 2016; Utami et al., 2019).

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Much research has been done on the implications of CTS, its assessment, and how to teach it (Ali & Awan, 2021; Arifin et al., 2025; Butcher et al., 2023; Chusni et al., 2021; Giri & Paily, 2020; Smith & Holmes, 2020; Stephenson & Sadler-Mcknight, 2016; Sutiani, 2021; Warsah et al., 2021). A lot of research using skill indicators such as Facione, Facione, and Sanchez (1994) (Ma & Chen, 2023), Facione (1990) (Gencer & Dogan, 2020), Facione (1990 & 2015 ) (Rowe et al., 2015), and Ennis & Millman, 1985 (Vieira & Tenreiro-Vieira, 2016). However, research that uses skill indicator modification thinking from many experts is still seldom done. This is important to gain new insights into assessing students' critical thinking skills. The formulated CTS indicators can be a basis for novelty for further research. Therefore, it is needed to study deeply to develop skill indicators and think critically based on studies from many experts in the field. This article is a review of CTS that focuses on the formulation of critical thinking skills indicators that are analyzed and synthesized from the opinions of several experts. This research review, in a way, comprehensively thinks of critical skills as competencies that can be observed and measured, especially for preservice physics teachers.

## 2. Method

This qualitative study uses content analysis to review documents with the theme of CTS (Fitzgerald, 2012). Data collection techniques used purposive sampling to analyze documents (Nyimbili & Nyimbili, 2024). Therefore, the data source in the study is the latest review draft of the results study, thinking about designs from books, proceedings, and journals. Data is analyzed carefully to identify patterns, themes, and related variables with CTS. Next, data triangulation is carried out. Compare and check information from various sources to ensure the validity and reliability of findings (Booth et al., 2021; Purwasih et al., 2024). The results of the analysis were used to identify the relevant indicator of CTS. The steps of document analysis in this study are shown in Figure 1.

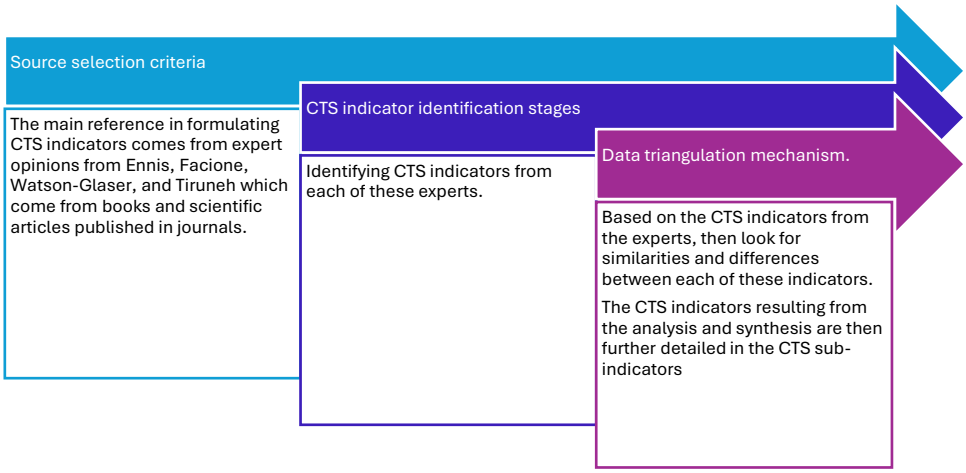


**Figure 1. The steps of document analysis in this study**

## 3. Results and Discussion

### 3.1. Aspect CT

The CT aspects used in this study were synthesized from various CTS experts, such as Facione, Ennis, and Watson-Glaser. The following is a synthesis of Table 1, which shows the framework's conceptual capabilities for CT.

**Table 1. Aspects CT from the Experts**

| Facione (1990) | Ennis (1996) | Watson-Glaser (2008) | Tiruneh (2014) | Synthesis Researcher |
|---|---|---|---|---|
| - | Clarity | Recognition Assumption | Hypothetical Analysis | Clarity Assumption |
| Interpretation | Situation | Interpretation | - | Interpretation |
| Analysis | Focus | - | - | Analysis |
| Explanation | Reason | Deduction | Reasoning | Reason |
| Inference | Inference | Inference | argument analysis | Evaluation |
| Evaluation | - | Evaluation of arguments | | |
| Self-regulation | Overview | - | likelihood and uncertainty analysis | Self-regulation |
| - | - | - | problem-solving and decision-making | |

## 3.2. Definition of Operation of Each Aspect CT

### 3.2.1. Clarity Assumption

In context CT, "Clarity Assumption" can refer to one of the assumptions adopted when developing the ability to CT. This assumption underlines the importance of good clarity and understanding of information, arguments, or statements before we start evaluating, compiling arguments, or making decisions.

Clarity assumption: This is based on the understanding that to think critically, we need to clarify concepts, definitions, and relevant information before (Heard et al., 2020; Hitchcock, 2017). Without a clear understanding, we risk making an inaccurate or even wrong conclusion. According to Ennis (1996), clarity is the ability to give a simple explanation with indicators consisting of a) focusing or formulating questions, b) analyzing arguments, and c) clarifying or answering questions. Watson-Glaser's (2008)opinion on indicator recognition assumption indicates that one of the characteristics of thinking critically is realizing suspicion or prejudice not written in the statement or the given premise. Therefore, the indicator clarity assumption is defined as the ability of students to analyze related statements or questions based on the information presented.

In context, operational clarity assumption becomes a characteristic of students who have the ability to think critically and can sort relevant information with ongoing problems completed (Belecina & Ocampo, 2018; Paul & Elder, 2019; Saputro et al., 2022). Testing-related indicator clarity assumption can be done with various information, information tiered, or digging into information from diverse sources to solve the problem. Many important points related to the clarity assumption in CT are:

**Clarification Draft,** Important for understanding the concepts used in an argument or statement. This includes defining the term key, understanding underlying assumptions, and identifying the connection between concepts. Physics involves complex and abstract concepts, such as force, energy, momentum, electric field, etc. Assumption of clarity pushes students to clarify concepts. This is Good before building understanding continues. For example, understanding what you mean by the "law of eternal energy" or "Newton's law of motion" is important before applying it to physics problems.

**Understand Argument,** Before evaluating an argument's strengths or weaknesses, we need to understand it entirely. This includes identifying premises and conclusions and determining whether the argument is deductive or inductive. In physics, many theories, laws, and models explain phenomena in nature. Students must be capable of understanding underlying argument concepts, such as premises and conclusions. The assumption of clarity allows students to critically evaluate the argument and understand based on the thinking behind the statement in physics.

**Clarifying Goals**, It is important to understand the objective or the problem you want to solve before looking for a solution or making a decision. We may have an irrelevant solution without a clear understanding of the goal.

**Evaluation** Source Information, Before using information from various sources, we need to ensure that it is clear, accurate, and reliable.

### 3.2.2. Interpretation

Ability interpretation is a CTS that involves the ability to understand, analyze, and interpret information or data precisely and objectively. The interpretation process often involves determining the meaning of the information provided, identifying patterns or relationships, and forming conclusions based on existing evidence (Heard et al., 2020; Schünemann et al., 2019).

Facione (1990) states that someone who has the ability to CT can be determined by their ability to interpret a meaning. Some characteristics of interpretation, according to Face, are grouping, interpreting sentences, and explaining the meaning/ intent of symptoms found. This is one's equality with indicator skills, think criticism expressed by Ennis (1996) regarding situation. Situation refers to finding an answer using all the appropriate information about the problem. This hints that students are required to process existing data to solve the problem. Watson-Glaser (2008) more carry on states that the characteristics of someone who has the ability to CT are how the person is capable of interpreting information, measuring evidence, and determining whether a generalization or conclusion based on the data that has been given is true. So, in the study, this indicator interpretation refers to the ability of students To interpret data or information provided in multi-representation form. The format can be checking, repeating, agreeing, objecting, or repairing false statements based on data.

Ability interpretation in learning physics at least refers to two main conditions. The first condition is understanding the context problems and conditions (Adams & Wieman, 2015; Ma'Ruf et al., 2020). The second is the time to understand the context findings from the settlement problem. This is to remember that sometimes,

settlement problems can be found with an experiment. Thus, the ability to interpret is very necessary to give meaning to the findings and results of experiments. Aspects important from ability interpretation in context, think critically is:

**Analyze Information**, Ability interpretation covers skills in analyzing information carefully and critically. This includes separating relevant information from the not relevant, identifying fact from opinion, and recognizing underlying assumptions information mentioned. In learning physics, students must be capable of analyzing information from various sources, such as textbooks, experiment laboratories, or collected data. Analysis information This helps students understand the concepts of physics and how various phenomena are explained by the laws of physics.

**Look for Meaning**, Interpretation involves effort. For example, you look for the meaning behind the information provided. This can include identifying the objective or the message you want delivered by the speaker or writer. In learning physics, students must be capable of looking for the meaning behind the concepts and formulas that are studied. They must recognize the meaning of every variable, parameter, and symbol used in equality physics.

**Draw a conclusion**, Based on analysis information, the ability to interpret allows somebody to make interesting, rational, and logical conclusions. This involves connecting various facts or evidence and making conclusions supported by the available evidence. For example, students must be able to draw interesting conclusions from the experiment or the data they observe. For example, they can conclude relatedness between variables or construct a physics model that can used to predict behavior systems.

**Identifying Patterns and Relationships**, Interpretation can also cover the ability to recognize patterns or connections between information or the data provided. This helps in understanding how various elements relate to each other. Students must be capable of identifying patterns and relationships mathematically in phenomena physics. For example, in motion bullets, they can recognize the connection between time, distance, and speed.

**Avoiding Bias**, Ability good interpretation also requires somebody to avoid bias and assumptions personal who can obstruct objective understanding. In the process of understanding and interpretation, students must try avoiding biases and assumptions that can bother understanding objective about draft physics.

**Interpreting Data**, In the context of data and statistics, interpretation involves the ability to understand results analysis statistics and recognize trends and interesting conclusions right from the existing data. Students must be capable of interpreting data from experiments or observations to understand the connection between variables and apply concepts relevant to physics.

**Put in Context**, Effective interpretation also involves putting information in the right context. This means considering the background, situation, or context in which the information is given to understand its wider implications. Learning physics often relates to situations in life daily or in real contexts. Students must be able to put draft physics in context to understand its application in the real world.

### 3.2.3. Analysis

The analysis indicates activity in testing ideas, recognizing opinions, and analyzing opinions. According to Ennis (1996), the analysis included in the indicator focus is the ability of students to understand the context of the problem that will be completed. Synthesis results from two indicators of CTS produce the indicator analysis used in the study. An indicator refers to the ability of students to analyze the information provided and test the truth of information by referring to concepts based on applicable science.

Aspect analysis is very important in context physics and is one of the elements key to thinking critically about concepts of physics and phenomena nature (Hidayat et al., 2024; Jamil et al., 2024; Wulandari et al., 2021). Here is a connection between aspect analysis and context physics:

**Reason Analyzing Data**, Data analysis is the process of collecting, organizing, and interpreting data from tests or observations. Students of physics must be capable of analyzing data carefully to understand patterns, trends, or connections between variables involved. This data analysis helps students make conclusions and take relevant information to test hypotheses or evaluate drafts of physics.

**Analyze Graphs and Diagrams**., Graphs and diagrams are important tools in visualizing physics data. Students of physics must be capable of analyzing graphs and diagrams to identify trends, see changes, or look for critical values. Analysis helps students understand the data better and take information from representation graphics.

**Analyze Physics Problems**, When learning physics, students are often faced with problems that require analysis and calculation. Analyzing problems in physics requires a deep understanding of relevant physics, identification of the variables involved, and formulation of strategies to solve them.

**Analyzing Physics Theories and Laws**, Physics has various theories and laws that explain phenomena. Students of physics must be capable of analyzing theories carefully, understanding the thinking behind them, and identifying how theories are applicable in various situations.

**Analyzing Physics Solutions**, When students finish problem physics, analysis solutions are a step important in CT. Students must be capable of investigating the eligibility and accuracy of the solution they give and inspect whether the solution is consistent with concepts applicable to physics.

### 3.2.4. Reason

The reason aspect or reason is an element key to CT and has a role in learning physics. Reason or reason is a runway for CT in physics (Bao & Koenig, 2019; Paul & Elder, 2019; Tiruneh, 2017). The ability to make a logical, supportive conclusion with appropriate evidence and identify biases or assumptions helps the students understand draft physics more in-depth. In addition, the ability to connect draft physics with the real world and do comprehensive analysis is also important from the reason aspect of learning physics.

Indicator reason refers to the ability of somebody to give an explanation related to an ongoing case discussed. Facione (1990)defines indicator reason as an explanation of ability. For state, the reasoning process results in a person's ability to justify a reason based on evidence, concept, methodology, criteria-specific considerations, and considerations that go into it, reason with subskill stated results, explain the method, and put forward an argument. Ennis (1996) carries on to explain that for state A reason, students must give a reason based on relevant facts/evidence at each step in making a decision and also the conclusion.

Different things as explained by Watson-Glaser (2008), the indicator deduction aims to decide whether a conclusion must follow data from the statement or the premise that has been given. Of the three opinions mentioned, the reason indicator in the study Is defined as the ability of a student to give an explanation/reason related to the conclusion that has been made based on facts/evidence that exist in case problems. Here are the connection reason indicators in context learning physics.

**Make Logical Physics Arguments**, Ability to make an argument in physics based on very related reasons and context. Students must be capable of compiling logical and consistent arguments based on concepts and principles of physics. Ability to connect premise with conclusion in a rational way and use reasoning deductive or inductively as appropriate.

**Supporting Conclusions with Appropriate Reasons**, This ability also overlaps with context learning physics, where students must support the conclusions with proper reasons and relevant evidence. This includes quoting law or theory applicable to physics, as well as presenting data or results supporting experiments' arguments.

**Identifying and Avoiding Bias**, Reason or reasons also involve the ability to identify biases or assumptions that may influence the understanding or conclusions of somebody about draft physics. With awareness of this bias, students can avoid errors in possible reasoning.

**Connect Physics Concepts with Real Cases**, Reason in physics involves the ability to connect concepts of physics with situations in life daily or case real. Students must explain how draft physics is applied to nature or the technology that is around them.

**Make Comparisons and Analysis**, Reasons are also possible for students to make comparisons between various draft physics or models, as well as do an analysis of the advantages and disadvantages of approaches in breakdown problem physics.

### 3.2.5. Evaluation

Evaluate refers to the ability of students to choose and decide opinions and existing evidence. In relation to the ability to think critically, as put forward by Facione (1990), the indicator evaluation refers to the ability of a student to evaluate rebuttal and judgment opinion given. Watson-Glaser (2008) explains that the argument evaluation indicator refers to the ability of a student To differentiate between strong and relevant arguments with weak arguments or No relevance to an issue. In research, indicator evaluation developed as a synthesis from two definitions of ability evaluate from Facione (1990) and Watson-Glaser (2008)formulated that evaluation is the ability to choose, evaluate, and decide on a statement or arguments given based on the

information presented. Students are expected to be capable of determining and creating relevant arguments with cases presented in multi-representation.

Different from his predecessor, Tiruneh (2014), particularly, tried out aspect evaluation in the realm of arguments presented. Both the evaluation and analysis argument are important in CT in physics. Second aspect: This allows students to compile and evaluate relevant arguments based on existing evidence and data. Evaluation and analysis of arguments in physics allow students to develop the ability to think strongly and critically (Bhakti et al., 2023; Salazar et al., 2023). By analyzing an argument in an objective way, using evidence physics, and identifying the strengths and weaknesses of the argument, students can hone CTS and strengthen their understanding of the concepts of physics. Relation second aspect This is as follows:

**Evaluation Argument**, Evaluation argument refers to the ability student To evaluate arguments presented by others, books, texts, or source information from others. Evaluation This involves identifying the strengths and weaknesses of the argument mentioned, as well as considering the validity and credibility of source information. Students must submit questions critical about the argument, search for supporting evidence, and assess the conclusions drawn.

**Analysis Argument**, Different contexts with evaluation and analysis arguments involve the ability to compile the argument yourself and present it clearly and organized. In physics, students must be capable of connecting the premise or data with the conclusion in a logical way. Analysis also involves identifying the connection, causality, or correlation between relevant variables in the argument.

**Use Physics Evidence**, As one of the ethics sciences, in the process of evaluation and analysis argument, students must be capable of using proof or valid and relevant physics data. This can be in the form of experimental data, results calculation, or fact scientifically verified. The use of evidence-proper physics supports the validity of arguments and conclusions drawn.

**Assumption Evaluation**, Assumptions are not inseparable from learning physics. So, students must also be capable of identifying underlying assumptions in an argument or draft of physics. Evaluation assumptions allow students to realize the limitations and restrictions of the argument. With the recognition of assumptions, students can avoid withdrawing from conclusions that are not appropriate or invalid.

**Integrate Physics Concept**, Lastly, in analyzing an argument in physics, students must be capable of integrating relevant physics concepts to support or reject an argument. This ability involves a deep understanding of theory and law physics and the ability to apply concepts to an in-context argument.

The CTS instrument can be prepared by compiling the CTS indicators, and the CTS assessment can be carried out on preservice teachers, especially preservice physics teachers. This is based on the importance of preservice teachers mastering CTS to develop skills for children later in school (Jean & Jiar, 2016). One learning method that can optimize CTS is inquiry-based learning, which actively involves students in the learning process through questions and answers, exploration, and assessment and has been shown to improve CTS (Sutiani, 2021). This approach encourages students to engage deeply with the material and develop problem-solving skills. Involve children in problem-solving activities, such as self-organized games and learning initiatives, to help them practice critical thinking in a structured environment (Aadzaar & Widjajanti, 2019; Maina et al., 2016).

## 4. Conclusion

Related studies with the indicator CTS for preservice physics teachers highlight five main aspects: clarity assumption, interpretation, analysis, reason, and evaluation. With this indicator, preservice teachers can align students' needs with innovative learning strategies that are process and result-oriented.

## Author Contributions

M Misbah: Conceptualization, Methodology, and Writing - Original draft preparation and Editing. Ida Hamidah: Supervision. Siti Sriyati: Writing - Reviewing. Achmad Samsudin: Supervision. : Writing - Reviewing. Nor Farahwahidah Abdul Rahman: Writing - Reviewing. All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

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