

# Development and Analysis Validation Instrument Critical Thinking Heat Concept (CTHT) Using Rash Model

Siska Dewi Aryani<sup>1</sup>, Hera Novia<sup>1</sup>, Andhy Setiawan<sup>2\*</sup>

<sup>1</sup>Physics Education Program, Universitas Pendidikan Indonesia, Bandung, Indonesia.

<sup>2</sup>Physics Program, Universitas Pendidikan Indonesia, Bandung, Indonesia.

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Corresponding Author:

Andhy Setiawan

[andhys@upi.edu](mailto:andhys@upi.edu)

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**Abstract:** This research aims to design and determine the validity and reliability of critical thinking skills instruments related to heat concepts using the Rasch model. This research uses 4D research and development methods. The research subjects or validation trials were 193 Depok City High School students majoring in Mathematics and Natural Sciences who had studied heat concepts and content validation was carried out with six expert lecturers. Content validity data analysis used Aiken V Microsoft Excel calculations with a validity limit value of  $< 0.78$  and construct validity and reliability used the Rasch model. The results of data analysis show that the content validity of the instrument is valid and suitable for use with several revisions and expert input, while the results of content validity show a validity level of 43.21% with all valid items in the fulfilled category, while the Pearson and item reliability values show a value of 0.62 is in the sufficient category and 0.92 is in the very special category. The results of the statistical analysis trial showed that the instrument was significant and became a benchmark for further research in the application of students' critical thinking skills in learning.

**Keywords:** Critical thinking concept heat (CTCH); Model rasch; Validation

## Introduction

In order to improve critical thinking abilities must apply physics knowledge in real-world scenarios, and comprehend physics topics in depth (Sari & Paidi, 2019; Yusal et al., 2021; Jamaludin et al., 2022). Critical thinking is crucial when learning physics, day is a type of analytical abilities (Maknun, 2020; Ayuningsih & Muna, 2023). Studying physics can benefit from the application of critical thinking in a number of ways, including analysis and evaluation. Pupils need to be able to assess the accuracy of source data, evaluate the physical knowledge given, and recognize persuasive arguments. Additionally, according to Sya'Bandari et al. (2018) students need to be able to critically examine physical theories, experiments, or research findings and challenge any erroneous presumptions or conclusions. Physics challenges need students to be able to find

pertinent material, use the proper formulas or principles, and critically analyze the outcomes (Payu et al., 2023). Heat concepts are one of the physics ideas that may be formed through critical thinking abilities. Critical thinking can make use of pertinent concepts and physics principles (Putranta & Supahar, 2019), although heat is an abstract substance, it is used in daily life and may be learned through a variety of techniques (Gurcay & Gulbas, 2018; Agnezi & Festiyed, 2023; Kotsis et al., 2023). In order to teach critical thinking, evaluation techniques must be developed using a particular instrument.

One tool for critical thinking might be an essay test. There are benefits to essay tests: students can answer more freely and express their opinions; teachers can create tests more quickly and efficiently; and students can practice using normal language sentences (Amalia & Susilaningsih, 2014). Thus, the creation of an essay test

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as a tool for critical thinking is required. According to Illene et al. (2023) instruments are tools used to meet academic requirements for measuring a thing. The use of instruments in assessment activities is essential to ensuring the validity of the assessment design (Nuryanti et al., 2018; Mahdian et al., 2024). When gathering precise and trustworthy information, instruments play a critical role. The tools employed will assist researchers in gathering the necessary data.

The function of an instrument is to turn facts into data so that instruments that are used have good quality data that matches the facts (Henukh et al., 2024). Instruments play a crucial part in determining the quality of research because of their validity or the degree to which data obtained is mostly determined by the instrument's quality. If the instrument being used has a high quality, say legitimate and reliable, then the data obtained from it will reflect factual information or the current state of affairs (Jamaluddin et al., 2019). On the other hand, low-quality tools that are used in projects often have weak validity and reliability. In this case, the data obtained is also invalid or does not agree with the facts at hand, which may result in unexpected outcomes (Noris et al., 2024). Validity and dependability are the key factors that determine whether an instrument is of good quality or not. One of the analytical tools that supports testing the validity and reliability of instruments is the Rasch model.

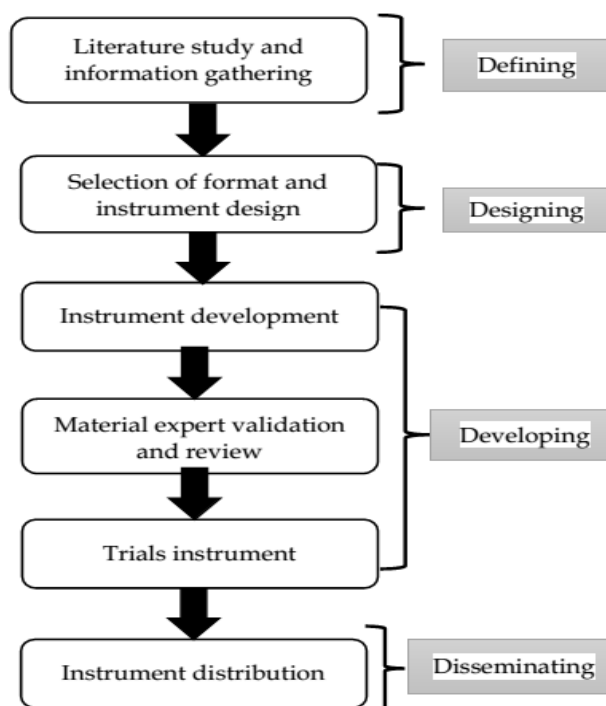
Software for evaluating polyatomic and dichotomous data is called the Rasch model (Samsudin et al., 2020). The instrument with item parameter and Pearson tests was prepared using the Rasch model. The Rasch model was created to assess data, including questionnaires, essays, multiple choice questions, and other forms. One benefit of Rasch analysis is that it can forecast missing data by using systematic response patterns. According to Sumintono (2018) the Rasch data analysis might be useful in analyzing the development of an instrument, including its validity and reliability. In addition, the Rasch analysis model has been widely applied in the field of statistics, namely in the fields of biology, chemistry, and physical science (Chan et al., 2014). Instruments in physics learning must be able to measure several types of skills, one type of skill that usually needs to be trained is critical thinking. This article aims to design and validate a CTHT instrument in physics, namely the heat concept using the Rasch Model.

The novelty of this research is that the researchers developed an instrument using new interpretations from previous research and different data analysis techniques, namely using the Rasch Model. Apart from that, the development has a different topic, namely more emphasis on fundamental concepts, namely the influence of heat on the temperature of objects, the

influence of heat on the shape of objects and the black principle. Researchers also use scoring techniques by developing their own criteria based on holistic assessments. In this research, the emphasis is on the use of Rasch analysis to obtain valid and reliable instruments.

### Method

Research method and design used in 4D instructional development (Defining, Designing, Developing, and Disseminating). The defining stage is carried out by collecting information through literature studies, identifying variables to be developed, making a list of objectives to be measured by the instrument (what), identifying target respondents, determining the scope (why) namely the steps involved in determining the objectives to decide how to use instruments, adapt them, or create original ones. At the designing stage, the format and design are selected by creating a grid of critical thinking skills instruments related to concepts in heat material. The development stage aims to develop critical thinking skills instruments as well as validate material experts and carry out revisions, and continues with the trial stage then analyzing its validity and reliability using Rasch. The final stage is disseminating, namely the instrument that has been created and implemented to students and introduced to teachers for use in learning. The following is a research flowchart as shown in Figure 1.



**Figure 1.** Research flow 4D instructional development (Defining, Designing, Developing, and Disseminating) (Thiagarajan et al., 2015)

## Result and Discussion

### Defining Stage

The test instrument developed aims to measure students' critical thinking skills. Critical thinking is a person's ability to be critical and objective in considering the information, arguments and evidence provided (Neswary & Prahani, 2022; Dalila et al., 2022; Permatasari et al., 2023). The research sample used was 193 Depok High School students majoring in Mathematics and Natural Sciences. The sample was determined randomly based on the criteria that the students had received material related to heat. The instrument used in this research is five questions describing five indicators developed by Ennis, namely seeking basic support, basic clarification, further clarification, strategy and tactics and inferences related to concepts in heat material (Ennis, 1993). Data analysis was carried out to determine the quality of the instrument as seen from instrument validity, item

validity, item reliability, and Pearson reliability using the WINSTEP software with Rasch Model analysis.

### Designing Stage

After going through the definition stage, the design stage continues. Aspects measured in critical thinking skills include indicators of building basic support, inference, further clarification, tactical strategy and basic clarification. The following is a description of each indicator of critical thinking skills: Scoring is carried out using holistic scoring 0-4 (Harsch & Martin, 2013). The scoring description is; 4: correct answer by providing a clear, focused and accurate explanation; 3: correct answer providing a clear, focused, but incomplete explanation; 2: the correct answer provides a clear explanation but lacks focus and is incomplete; 1: gave the answer but was wrong and 0: did not answer. At the design stage, the researcher created a critical thinking skills test instrument grid in the form of a description as shown in Table 1 below.

**Table 1.** Critical Thinking Heat Concept (CTHT) Indicators and Sub Indicators

Heat Concept	Critical Thinking Indicators and Sub-Indicators	Question Indicator	Item
The effect of heat on the temperature of objects	Basis for making decisions or support Assess observation reports based on criteria: observation Notes	Presented about simple experimental observations regarding the dissolving process. From the observational information provided in the question, students can criticize whether the connection between heat and the dissolving event given in the question is true or not.	1
Asas black	Inference: the existence of alternatives Assess definition: Report definition	A case regarding the application of the black principle is presented. From the information provided in the question, students can criticize whether an action is appropriate or inappropriate or whether there is a more appropriate action/solution other than the action taken in the question. Information is presented regarding experimental reports on the application of the black principle. From the experimental report information given in the question, students can decide what to believe and do by criticizing the accuracy/inaccuracy of the experimental report given in the question.	2 3
The effect of heat on the shape of objects	Strategy and tactics: interacting with others Answer clarifying questions	A discourse is presented regarding the relationship between the addition of salt and the melting point (freezing point). From the information provided in the question, students can criticize the logical strategies that can be used to respond to clarification of the information presented in the question. An illustration of a story about changes in form, namely evaporation, is presented. From the discourse given in the question, students can provide basic clarification by answering questions from those who ask for an explanation of the statement given in the question.	4 5

Based on Table 1, each question represents one indicator from the five indicators developed. Interpretation of the table shows that each measurement of several aspects has a different number of questions with each indicator measurement.

### Developing Stage

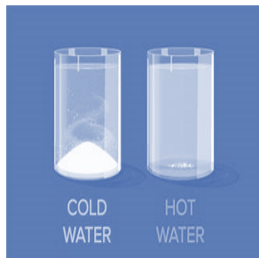
After the instrument design stage, the next step is to create questions describing critical thinking skills as in one of the indicators shown in Figure 2.

Based on Figure 2, a simple experimental observation regarding the dissolving process is presented. From the observational information provided

in the question, students can criticize whether the connection between heat and the dissolving event given in the question is correct or not. This research investigates the design of the instrument, content and construct validity as well as the reliability value of the instrument for testing critical thinking skills in physics, especially the concepts of heat which consist of the influence of heat on the temperature of objects, the influence of heat on the shape of objects and the black principle.

Solubility is the amount of solute that will dissolve into a solution to become a homogeneous solution. Solubility is related to the movement of molecules or the attraction of solute particles with solvent particles. The easier the solute, the faster the movement of the molecules, conversely, the harder the solute, the slower the movement of the molecules.

Next, Dila made observations in a simple experiment. He prepared two glasses, each filled with hot water and cold water with the same volume but different temperatures, namely 90°C and 3°C. To each water add one spoonful of sugar and stir for one minute. The observation results obtained by Dila from this experiment were that the amount of sugar dissolved in water at 90°C was more than in water at 3°C as shown in the following picture.



Based on the results of this observation, Dila stated "Heat affects the movement of molecules in substances". Is Dila's statement true? Explain your answer!

**Figure 2.** Example of a critical thinking description test instrument for basic aspects

The instrument will undergo content validation and evaluation prior to the completion of the grid design procedures and instrument format. Expert assessment based on critical thinking with regard to heat concepts was used to determine the content validity of the instrument in this study. If an expert thinks that the instrument will measure the ability to be measured, content validity is applied since a test or non-test instrument has been demonstrated to be accurate. Expert judgments can be made using the Aiken validity index (Retnawati, 2016). Content validity values were acquired from six assessors using the Aiken method from the validity assessment activities that were conducted, with a response scale of 5 = Very Appropriate 4 = Acceptable, 3 = Quite Acceptable, 2 = Inappropriate and 1 = Not Suitable (Harsch & Martin, 2013). The outcomes are displayed in Table 2 below.

**Table 2.** Aiken Index (Index V) of Six Critical Thinking Heat Concept (CTHT) Expert Validators

Item	Assessment Items			Conclusion
	Content Aspect	Construction Aspects	Language Aspects	
1	0.87	0.97	0.96	Valid
2	0.87	0.98	0.96	Valid
3	0.79	0.98	0.97	Valid
4	0.79	0.98	0.96	Valid
5	0.83	0.98	0.95	Valid

The critical thinking abilities test instrument yields five valid question items with a high validity category based on the calculation results. If the expert evaluation yields an Aiken validity index value that is less than 0.4, it is considered low. According to Aiken (1980), values with high validity exceed 0.8, whereas validity is defined as falling between 0.4 and 0.8. The item is better if its Aiken index value is closer to 1 since it is more indicative of the indication (Retnawati, 2016). Six experts' content validation results yielded recommendations and advice. These recommendations and comments include: several statements in the instrument test need to be readjusted to the indicators to be measured; editorial staff writing work instructions and statements need to adhere to PUEBI; and the indicators in question items 1 and 2 are similar in their criticism of the concept of heat.

The five critical thinking skills test items, as determined by the Aiken index analysis, are all valid; however, in order to make the test instrument relevant and effective for testing, certain editorial changes must be made. Revisions to the aforementioned statement items must also consider the assessors' recommendations and input. Following the completion of the statement item improvement activities, 193 high school students in the city of Depok participated in the instrument test development process to test the instrument and ascertain its construct validity. Respondents were selected based on the criteria that the respondents had studied the concept of heat. The trial was carried out over a period of one week because the respondents needed to consist of several levels to get more reliable results. The results of construct validity trials using the Rasch model are shown in Table 3.

**Table 3.** Critical Thinking Heat Concept (CTHT) Validity Test Data

Standard Residual	Expected	Interpretation
Raw variance explained by measures	43.21%	Valid

Table 3 displays the instrument's validity using WINSTEP Rasch program. The validity of an instrument has a minimum threshold of 20% (Ariffin et al., 2010). The raw variance measurement value of the critical

thinking skills essay test instrument is 43.2%, according to the validity report. Based on Chan et al. (2014), who found that an instrument validity value of more than 20% falls into the fulfilled group, it may be inferred that the critical thinking concept heat (CTCH) instrument is valid. Furthermore, as shown in Table 4 below, the degree of conformance is used to assess each statement item's validity.

Table 4 displays an analysis of the items' degree of suitability (item fit) the analysis's findings using the WINSTEP Rasch program. The measurement instrument's performance is determined by its item fit MNSQ criteria are  $0.5 < MNSQ < 1.5$ ; ZSTD is  $-2.0 <$

$ZSTD < +2.0$  and PT Measure Corr is  $0.4 < PT Measure Corr < 0.85$  with appropriate and non-suitable criteria (Ariffin et al., 2010). If an instrument satisfies three, two, and one of the criteria, it is still considered valid or appropriate; on the other hand, if it fails to meet any of the criteria, the CTCH instrument is deemed invalid or unsuitable (Alfarisa & Purnama, 2019). The five exam items for critical thinking skills demonstrate accurate and suitable interpretations. In addition to assessing the instrument's validity, a reality assessment was conducted to gauge the instrument's quality, as indicated in Table 5.

**Table 4.** Construct Validity Test Using Rasch Model Critical Thinking Heat Concept (CTHT)

Item	Outfit Value		PT Measure Corr	Value Criteria	Interpretation
	MNSQ	ZSTD			
1	1.07	0.75	0.63	Two criteria fulfilled	In accordance
2	0.99	-0.09	0.70	Two criteria fulfilled	In accordance
3	1.25	2.41	0.58	Two criteria fulfilled	In accordance
4	0.87	-1.38	0.63	Two criteria fulfilled	In accordance
5	0.78	-2.43	0.62	Two criteria fulfilled	In accordance

Table 5 displays the WINSTEP Rasch software that was used to assess reliability. Rasch analysis results indicate that item and Pearson reliability are, respectively, 0.94 and 0.62. The reliability results demonstrate that the CTCH instrument is highly appropriate for use, with the Pearson reliability value indicating that the consistency of students' answers falls into the enough category and the reliability item indicating that the instrument's reliability falls into the very special category. The present study's findings are consistent with those of Syahfitri et al. (2019) who demonstrated that thinking tests in the field of biology possess strong construct validation and content validity. According to research Sya'Bandari et al. (2018) that looked at instruments connected to critical thinking, 73% of students' critical thinking profiles fell into the medium range. According to research, students' critical thinking abilities can be assessed based on their ability to meet learning objectives, such as participating in conversations and responding to questions (Rahayu & Sapriati, 2018; Ariffin et al., 2010; Matsun et al., 2023; Chairatunnisa et al., 2023). Critical thinking is a skill that needs to be measured and trained in learning, one of which is by using instruments as a benchmark for the extent to which critical thinking skills already exist in students (Saregar et al., 2018; Mahbubah et al., 2018; Anggraeni et al., 2019; Malik et al., 2019). This is reinforced by the statement that the more critical thinking is practiced, the more cognitive results and knowledge about higher level thinking can be reached by students (Suci et al., 2022; Puteri et al., 2023).

**Table 5.** Instrument Reliability Test Using Rasch Model Critical Thinking Heat Concept (CTHT)

Person reliability	0.62	Enough
Item reliability	0.94	Very special

*Disseminating Stage*

The product distribution stage is the final stage of the process of developing a test instrument for describing critical thinking skills related to concepts in heat material. In this process, the developed instrument was distributed to several upper secondary schools to be used by class XI MIPA students studying heat concepts.

**Conclusion**

From the results and explanations related to the development and validation of students' critical thinking skills instruments related to heat concepts and consisting of five descriptive questions developed based on Ennis indicators, it shows that the content validity is considered valid and suitable for use with several revisions and expert input, while the validity results The test results of the construct on 193 students showed a validity level of 43.21% with all valid items in the usable category, while the Pearson and item reliability values showed a value of 0.62 in the sufficient category and 0.92 in the very special category. Therefore, critical thinking skills instruments can be used and applied in measuring students' critical thinking skills regarding heat concepts in learning.

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### Author Contributions

Conceptualization, S. D. A, H. N, A. S.; methodology, H. N.; validation, A. S. and S. D. A.; formal analysis, A. S.; investigation, S. D. A.; resources, S. D. A. and H. N.; data curation, R. A. E.; writing—original draft preparation, M. N. S and S. D. A.; writing—review and editing, S. D. A.; visualization, and A. S. and S. D. A. All authors have read and agreed to the published version of the manuscript.

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### Conflicts of interest

The authors declare no conflict of interest.

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