Construction and testing of decision-problem solving skills test instruments related basic physics content

Y Yusal1*, A Suhandi2, W Setiawan3, and I Kaniawati4

1Program Studi Doktoral Pendidikan IPA, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229, Bandung 40154, Indonesia
2,4Departemen Pendidikan Fisika, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 229, Bandung 40154, Indonesia
3Program Studi Pendidikan Ilmu Komputer, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229, Bandung 40154, Indonesia

*Corresponding author: yulianti_yusal@student.upi.edu

Abstract. The aim of this study is to produce test instrument items decision-problem solving skills related to the content of Heat Transfer. The construction of the test instrument has been done using scaffolding which includes stages: description of indicator of decision-problem solving skills, operationalization of indicators, construction of items scenarios, writing of test items, validation of test items, and test of reliability. Validation of test items has been done by five experts namely three education evaluation experts and two physics experts. Test of reliability was carried out by involving 35 students of physics education program at one of the universities in South Sulawesi province. The construction process of the test instrument produced two items of test decision problem solving skills related to the concept of conduction and heat radiation. The results of expert validation of the decision-problem solving test items stated that the constructed items had high validity, and the results of the test reliability showed that the constructed test instruments had a high degree of consistency permanence. These results indicate that the product of decision-problem solving test instrument is worthy of being used for measuring decision-problem solving skills for students of Physics education programs who contract Basic Physics courses.

1. Introduction
The challenges of globalization are increasingly severe in this 21st century era. Education in tertiary institutions should be able to create competent human resources in the 21st century, those that master the various skills needed in facing the challenges of the 21st century. Decision-problem solving skills, one of 21st century skills, should be prepared by students to face the challenges of the 21st century [1,2]. Decision making is one of the complexes thinking skills [3]. Therefore, it is very important to be trained and developed in the learning process in college. This can be used by students after graduation as a means of living in society, especially when facing increasingly complex problems and fierce competitions. However, the average decision-making skills possessed by students are still low category [4,5].

The briefing of decision-problem solving skills is done by integrating it into the content of the learning instructions that are being designed [6]. In the teaching and learning process, the students’ decision-problem solving skills are trained through the use of various teaching models. Therefore, it is
important to establish a valid measurement that is able to accurately measure the students’ learning outcomes based on the aspects of decision-problem solving skills.

Courses that can help students to develop decision-problem solving skills are science subjects [7,8]. Students agree that decision-problem solving can be led by science subjects [9]. However, related to the content of physics, the decision-problem solving skills test is still rarely developed by researchers. The content of heat transfer is one of the contents of physics that its concept is widely used in decision-problem solving in daily life. Therefore, the aim of this study is to produce a test instrument of decision-problem solving skills related to the content of Heat Transfer.

2. Methods
The construction test instrument is carried out using scaffolding which involved some stages: description of indicator of decision-problem solving skills, operationalization of indicators, construction of items scenarios, writing of test items, validation of test items, and test of reliability [10]. Figure 1 shows the schematic of the scaffolding for construction an instrument test item resulted in the development stage.

![Scaffolding for construction of instruments test item of decision-problem solving skills](image)

Validation of the test items was conducted by five experts, namely three education evaluation experts and two physics experts. Suggestions given by the experts were used as input to improve the decision-problem solving skills test to obtain a revision version of the test instrument. The validation result by experts was then be calculated using the Content Validity Ratio (CVR) shown by equation [11]:

\[
CVR = \frac{N_e \cdot N/2}{N/2}
\]

with \( CVR \) is the ratio of content validity, \( N_e \) is the number of experts that claim valid, and \( N \) is the number of experts to validate. CVR values obtained from the calculations were compared to the minimum value of CVR based on the number of experts as listed in Table 1 [12].
Table 1. Minimum one-party CVR test value, $p = 0.05$

| Number of validators | Minimum value of CVR |
|---------------------|----------------------|
| 5                   | 0.736                |
| 6                   | 0.672                |
| 7                   | 0.622                |
| 8                   | 0.582                |
| 9                   | 0.548                |
| 10                  | 0.520                |
| 11                  | 0.496                |

To determine the reliability of the test instrument, the decision-problem solving skills test was tried out to 35 students of the Physics education program at one of the universities in the South Sulawesi province. The test results were calculated using the Cronbach-alpha reliability test shown in equation [13]:

$$r_{11} = \left(\frac{n}{n-1}\right) \left(1 - \frac{\sum \sigma_i^2}{\sigma_T^2}\right)$$  \hspace{1cm} (2)

with $n$ is the number of test items, $\sum \sigma_i^2$ represents the number of variances for each item, and $\sigma_T^2$ is the total variance. The reliability coefficient $r$ obtained is then interpreted using Table 2.

Table 2. Categorization of Item reliability

| Score Range | Category     |
|-------------|--------------|
| 0.80 ≤ $R$ ≤ 1.00 | High         |
| 0.60 ≤ $R$ < 0.80  | Rather High  |
| 0.40 ≤ $R$ < 0.60  | Medium       |
| 0.20 ≤ $R$ < 0.40  | Low          |
| 0.00 ≤ $R$ < 0.20  | Very low     |

3. Result and Discussion

The construction of the test instrument was carried out using a scaffolding test item which included several stages. At the stage of description, the indicators of decision-problem solving skills followed by operationalizing of indicators, it was obtained that the aspects to be used are the ability to make decisions. Problem solving and decision making are two things that are interrelated, where solving a problem requires decision-making skills [14]. The aspects of decision-making ability are elaborated into two items of decision-problem solving skills tests related to the concept of conduction and heat radiation.

At the stage of making scenario items and writing test items, the results obtained are in the form of decision problems, for example, dilemmatic problems often found in everyday life. Thus, decision making was required. The types of problems faced by students affect the problem-solving framework used [13]. The test item of decision-problem solving skills, which is in the form of a decision problem, is equipped with data that require students to consider the criteria of these data.

There were several important activities conducted at the stage of writing test items, including arranging items based on the concept of Heat Transfer and aspects of decision-problem solving skills, namely decision-making abilities, making assessment guides for decision-problem solving skills, and reviewing all items and assessment guides. These were done to examine the suitability of the question items with the aspects of decision-problem solving skills to be measured, clarity of the questions, and
completeness of the sentence construction. In addition, in this stage, the suitability of the criteria used to assess each part of the student's answer was also reviewed. As a result, these stage activities, the initial version of the decision-problem solving skills test was created.

Yulianti is asked by her mother to buy a pan in a furniture shop. The pan that Yulianti's mother wants is a pan that quickly boils water at economical prices. In household furniture stores, there are several types of pans available of the same size (glass thermal conductivity = 0.78 K (W/(m °C)), Stainless steel = 15 K (W/(m °C)), and Aluminum = 237 K (W/(m °C)).

| Choices | Picture | Material | Material of pan cover | Colour | Price (Rp) |
|---------|---------|----------|-----------------------|--------|------------|
| 1       | ![Aluminium Glass Silver 71.500,00](image1) | Aluminium | Glass | Silver | 71.500,00 |
| 2       | ![Aluminium Aluminium Silver 71.500,00](image2) | Aluminium | Aluminium | Silver | 71.500,00 |
| 3       | ![Aluminium Glass Black 72.000,00](image3) | Aluminium | Glass | Black | 72.000,00 |
| 4       | ![Aluminium Aluminium Black 72.000,00](image4) | Aluminium | Aluminium | Black | 72.000,00 |
| 5       | ![Stainless steel Glass Silver 115.500,00](image5) | Stainless steel | Glass | Silver | 115.500,00 |
| 6       | ![Stainless steel Stainless steel Silver 115.500,00](image6) | Stainless steel | Stainless steel | Silver | 115.500,00 |
| 7       | ![Stainless steel Glass Black 120.000,00](image7) | Stainless steel | Glass | Black | 120.000,00 |
Stainless steel, Stainless steel, Black, 120,000.00

Figure 2. Example of decision problem

Which type of pan is the best to choose to meet the need of Yulianti’s mother?

Questions:
(a) Determine the basis used for making decisions for the decision problem above!
(b) Determine the advantages and disadvantages of each choice of decision problem based on the bases specified in point (a)! Explain each of these advantages and disadvantages!
(c) Based on the explanation of the advantages and disadvantages of each choice in point (b), determine which choice is the best choice as a problem solving for decision problem above!

Figure 3. Questions for decision problem

The initial version of the decision-problem solving skills test was reviewed by five experts, three of them were education evaluation experts and two others were physics experts. The testing of decision problem solving instrument validity was done by using four assessment criteria, namely: (1) the content of the test items must meet the indicators of decision-problem solving skills; (2) the contents of test items do not contain conceptual errors (misconceptions); (3) the key answers do not contain errors; and (4) grammar used must be correct based on Indonesian language rules. The validated test instruments resulted were two test items containing aspects of decision-making ability. The recapitulation of CVR values for each item of decision-problem solving skills is shown in Table 3.

Table 3. Recapitulation of CVR Values for each item item and assessment criteria

| Question | Criteria 1 | Criteria 2 | Criteria 3 | Criteria 4 | Average Score | Remark |
|----------|------------|------------|------------|------------|---------------|--------|
| 1        | 1          | 1          | 1          | 0.75       | 0.937         | Valid  |
| 2        | 0.75       | 1          | 0.75       | 0.75       | 0.812         | Valid  |
| Average  | 0.875      | 1          | 0.875      | 0.75       | 0.875         | Valid  |

Table 1 shows that the CVR value for five validators is 0.736. Based on Table 3, it is obtained that, validity testing process on the decision-problem solving skills test instrument shows the average CVR value that exceeds the minimum threshold of 0.875. This indicates that the instrument is a valid decision-problem solving skill test. Although the problem solving skills test instrument is declared valid, there are some suggestions from the validators. Some suggestions for revisions provided by the validators are corrections on some sentence construction, writing symbols used on the table, grammar mistakes (violation of the rules of Indonesian language); completion on the context of problems; and adjustment of the sentence to problem contexts.

Tests for the revised decision-problem solving skills were tried out in the field. The score of the decision-problem solving skills test obtained was used to determine the reliability of the item through the Cronbach alpha reliability test. Based on the test results gained, the reliability value of the test instrument decision problem solving skills is 0.65. The results of this data analysis indicate that the reliability of test instrument of decision-problem solving skills constructed was in high category. The construction of this instrument is appropriate for assessing student decision-problem solving by involving the concept of student heat transfer. Meanwhile, the construction of the existing decision-problem solving instrument is only suitable for assessing student decision-problem solving without involving students' physics concepts [16].
4. Conclusion
In this study, a test instrument for decision-problem solving skills has been constructed. It consists of two questions related to the concept of conduction and heat radiation. The results of the validity test that has been done by experts and the results of the calculation of the reliability of the instrument is obtained that the problem solving skills test instrument has good quality. Thus, it is feasible to be used for evaluating students’ decision-problem solving skills both in the learning process of Physics at the university level and in any relevant research activities.

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