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The Development of HOTS-based Question Instrument in Temperature and Heat Material

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Abstract: This study aims to develop HOTS question instruments in temperature and heat material. This study uses the design thinking method with five steps including empathize, define, ideate, prototype, and test. The test stage was conducted with a one-shot case study and quantitative descriptive analysis. Sampling was conducted by using purposive sampling technique on 25 students in eighth grade. The HOTS question instruments developed in thirty multiple choices. The results of instrument quality according item analysis test in terms of the level of difficulty is in a medium average with a good category, the distinguishing power is 0.66 with a good category, the validity of instrument is 63.3% with valid category, and the reliability of instrument is 0.78 that declared reliable. So, it can be said that the instrument that has been developed is feasible to use.

Keywords: Design thinking method; Hots; Question instrument

Introduction

Higher Order Thinking Skill (HOTS) is an ability that must be possessed by every implementer of educational, both teachers and students in order to conduct learning in the 21st Century. Mardhiyah, et al (2021) explained that this learning more emphasis on students-centered learning, where the learning process is expected to involve and develop high-level thinking skills. These thinking skills include critical thinking, problem solving, meta-cognition, communication, collaboration, innovative and creative thinking, and literacy skills. If it can be implemented optimally, HOTS will have a positive impact to increase the skills quality of students who are proficient in education.

HOTS can be defined as an ability that focuses on using cognitive abilities in absorbing, analyzing, and processing the information to solve the problems (Nailya et al., 2015). Bloom divides the cognitive level into 6 components, namely the ability to remember (C1), explain (C2), apply (C3), analyze (C4), evaluate (C5), and create (C6). Kristanto and Setiawan (2020) explained that the cognitive domain in Bloom's Taxonomy is divided into three parts, there are LOTS (Lower Order Thinking Skill), MOTS (Medium Order Thinking Skill), and HOTS (Higher Order Thinking Skill). Basic level of thinking skills (LOTS), can be interpreted as cognitive abilities in remembering and repeating information that was previously given, while HOTS is a cognitive ability to connect an idea or theoretical science through events or phenomena that occur. By using HOTS, students can use their cognitive abilities to analyze and evaluate the phenomena, and make creative ideas to solve the problem (Helmawati, 2019). Another of that, enhance the HOTS ability can be train the critical thinking of student in receiving various type of information, creative problem solving and make decisions in complex situations (Hartono et al., 2022).

But, HOTS ability of Indonesian students are still very low. This is proven by the results of Program for International Student Assessment (PISA Test), where Indonesian students HOTS level in science literacy were ranked 74 from 79 countries. Almost all Indonesian students only competent the lessons until cognitive level

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three on six cognitive levels has been tested, while students in other countries are able to solve problems in cognitive domain 4 (four), 5 (five), and even 6 (six). Another fact is also conveyed by Trends in International Mathematics and Science Study (TIMSS, where in Science and Mathematics skills of grade IV and grade VIII in 2015 were ranked 45th from 50 countries with 397 points (Kemendikbud, 2019).

The low level of students' HOTS obtained because students are not understanding and familiar in solving HOTS-based questions (Kusuma et al., 2017). This high-level thinking ability can be trained to students through habituation in solve questions on HOTS-based test (Rahmawati, 2023). This habituation can be implemented by teachers with developing HOTS questions that are able to provide stimulus which can grow the thinking abilities of students. The stimulus can be contextual and interesting that comes from daily life. It can use current issues, phenomena, environmental problems, culture, local wisdom, and so on (Kristanto et al., 2020).

The quality and variety of stimulus questions in the preparation of HOTS questions are influenced by the knowledge and creativity of the teacher. Facts in real life show that some teachers have an incorrect to understand of HOTS concept (Anggraeni et al., 2020). Miarsyah and Ristanto (2019) in their research explained that some teachers think that HOTS questions must have a high level of difficulty. It makes a goal of learning process to improve students' HOTS is difficult to achieve. Therefore, by providing and training to solve HOTS based questions regularly and variedly, students will get cognitive abilities optimally (Rahayu et al., 2023).

When viewed from the material, the way to enhance the HOTS abilities of student, it can be trained through relevant natural phenomena that are linked in daily life and included in science learning process (Azizatunnisa et al., 2022). The material that use in this research is temperature and heat. The reason is because the topic has very close relationship with daily life. The implementation of temperature and heat concept can be related in working principles of tools in the home and the environment, it is also related in animal and human adaptation when hot and cold weather. Seeing the contextualization of the material, researchers are very interested in developing HOTS instruments on this material. The results of this study are expected to be used and utilized to education implementers, especially science teachers in designing and training students HOTS ability.

Method

This research was using the Design Thinking method. In this method, there are 5 steps, namely empathize, define, ideate, prototype, and test. By understanding of these 5 steps, the problems can be solved (Dam & Siang, 2020). The flow chart of this research is presented in Figure 1.

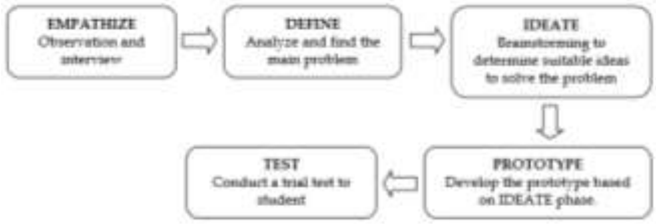

Figure 1. Research flow using Design Thinking

Empathize

At this stage, the researcher examined the higher order thinking skills level of students in Indonesia through research journals.

Define

After carrying out the first step, the researchers analyze to find and identify the main problems (Sari et al, 2020).

Ideate

In this step, the researchers will brainstorm to determine suitable ideas to solve the problem (Wibowo et al., 2020). The idea that emerged was about developing HOTS instrument on temperature and heat material.

Prototype

In this step, the purpose of prototyping is to realize the ideas that have been obtained at the ideate stage (Ambrose et al., 2010). The prototype is a HOTS question instrument on temperature and heat material.

Test

After the instrument has been declared feasible, then the prototype will be tested on students. In this testing step, the HOTS instrument would be tested on limited scope at SMPN 27 Surabaya. There were 25 students who participated in this research study.

The technique of analysis in this research was quantitative descriptive. According to Sugiyono (2014), this analysis technique aims to describe data in order to obtain an overview of the object of study with generally. And then, the instrument would be identified the level of difficulty items, the distinguishing power, validity and reliability of the instrument.

Result and Discussion

Based on the results of the test, the instrument was conducted to analyze the quality of the instrument. This analysis aims to determine that degree of instrument quality, both overall and each item (Arifin, 2012). This analysis includes level of difficulty (P), distinguishing power (DP), validity, and reliability of the instrument. The explanation is as follows:

Level of Difficulty (P)

The level of difficulty is a description that shows whether the question is easy or difficult to work on (Aziz, 2016). The item of questions can be categorized as difficult if the question has a small difficulty index. It is caused by low frequency of students in class population who answer the question correctly, so the item has a small difficulty index (Wantoro et al, 2019). The results of the identification of HOTS-based questions on temperature and heat materials can be observed in Table 4.

Table 1. The result of identifying of difficulty item

No. Item	P	Description	No. Item	P	Description
1	0.6	Medium	16	0.72	Easy
2	0.68	Medium	17	0.6	Medium
3	0.56	Medium	18	0.32	Medium
4	0.16	Difficult	19	0.68	Medium
5	0.68	Medium	20	0.44	Medium
6	0.48	Medium	21	0.64	Medium
7	0.56	Medium	22	0.72	Easy
8	0.44	Medium	23	0.56	Medium
9	0.4	Medium	24	0.8	Easy
10	0.56	Medium	25	0.8	Easy
11	0.28	Difficult	26	0.64	Medium
12	0.4	Medium	27	0.4	Medium
13	0.48	Medium	28	0.48	Medium
14	0.48	Medium	29	0.72	Easy
15	0.48	Medium	30	0.68	Medium

Based on the results of the test, the average of HOTS questions are defined in the "Medium" criteria. The items that have category "difficult" are number 4 and 11, with the difficulty index (P) 0.16 and 0.28. The items that are defined in the "Easy" category are number 16, 22, 24, 25, and 29 with the difficulty index on each item are 0.72; 0.72; 0.8; 0.8; and 0.72. According to Arikunto (2006), determining the feasibility of instrument needs to give attention to the purpose of using the test, if the test questions are used to determine achievement of student learning outcomes, test questions should be no too easy and too difficult. In accordance with Fatimah & Alfath (2019), they state that good questions are not too easy or not too difficult. Easy questions will not increase students' thinking ability, and if the questions are too difficult, students will lose motivation and tend to give up on doing the test. Based on that statement, it can be said that the HOTS instrument is good category, because the average of HOTS instrument has a "Medium" difficulty level.

Distinguishing Power (DP)

Distinguishing power is the ability of an instrument to distinguish between high and low ability of students (Daryanto, 2010). To identify this, the results of HOTS-based questions were compared between upper and lower group students. The technique was to take 27% of students who got high scores (upper group) and 27% of students who got low scores (lower group). Then the instrument was analyzed for distinguishing power by entering into the table of interpretation according to Arikunto (2003).

Table 2. The Criteria of Distinguishing Power

Distinguishing Power (DP) Value	Criteria
0.00-0.20	Weak
0.21 – 0.40	Medium
0.41 – 0.70	Good
0.71 – 1.00	Very strong
Negative sign	Very bad

The results of the Distinguishing Power (DP) value for each HOTS item that has been tested can be observed in Table 6 below.

Table 3. Distinguishing Power of Each Question Item

No. Item	DP	Criteria	No. Item	DP	Criteria
1.	-0.143	Very bad	16.	0.429	Good
2.	0.429	Good	17.	0.571	Good
3.	0.571	Good	18.	-0.143	Very bad
4.	0.286	Medium	19.	0	Weak
5.	0.429	Good	20.	0.571	Good
6.	0.429	Good	21.	0.571	Good
7.	0.286	Medium	22.	-0.143	Very bad
8.	0.571	Good	23.	0.143	Weak
9.	0.714	Very strong	24.	-0.143	Very bad
10.	0.714	Very strong	25.	0.429	Good
11.	0	Weak	26.	0.143	Weak
12.	0.571	Good	27.	-0.429	Very bad
13.	0.571	Good	28.	0.571	Good
14.	0.571	Good	29.	0.286	Weak
15.	0.571	Good	30.	-0.143	Very bad

Based on the results, the item questions that have category of distinguishing power "Medium", "Good", and "Very strong" are worth to use, while items questions that categorized "Very bad" and "Weak" are better not to use or deleted (Arikunto, 2003). The items that must be deleted are 1, 11, 18, 19, 22, 23, 24, 26, 27, 29, and 30 because those items are in the category "Very bad" and "Weak". After distinguishing the power of each item has been identified, the HOTS instrument is conducted to be analyzed to identify the feasibility of the

HOTS instrument. The results of calculation by using the instrument's distinguishing power formula is 0.66 with category "Good", so this instrument is suitable to use.

Validity of Instrument

Validity is an index that shows of an instrument can measures what its aim to measure (Sugiyono, 2003). It is also defined as the accuracy of the instrument in making measurements. Validity testing of the instrument can be reviewed through content and construction validity, involving experts to assess the feasibility of the instrument that has been developed. If the instrument is adequate based on content and construction validity, the instrument can be said to be suitable for use. Furthermore, the instrument is carried out by testing empirically validity, it was applied to the respondents would be studied. The aim of empirical validity is used to measure the validity of instruments based on facts in real situation. The data that has been collected, then calculated to find level of validity using Product Moment by Karl Pearson's formula as follows:

$$r_{xy} = \frac{n(\Sigma x_i y_i) - (\Sigma x_i)(\Sigma y_i)}{\sqrt{(n(\Sigma x_i^2) - (x_i)^2)((n(\Sigma y_i^2) - (y_i)^2)}} \quad (1)$$

The calculation by using Excel will get the number of r (correlation). Question items can be said to be valid if the calculated r-value is greater than the r-table (Sugiyono, 2014). Because the sample of this research was 25 students and the significant level is 5%, so the r-table value is 0.396. The r-table value can be found based on a table of r-product moment according to Sugiyono (2014). The result of validity data for each item was presented in Table 7 below:

Tabel 4. The result of each items validity

No. Item	r-count	Desc.	No. Item	r-count	Desc.
1.	0.009	Invalid	16.	0.427	Valid
2.	0.398	Valid	17.	0.463	Valid
3.	0.445	Valid	18.	-0.125	Invalid
4.	0.412	Valid	19.	0.035	Invalid
5.	0.421	Valid	20.	0.409	Valid
6.	0.397	Valid	21.	0.397	Valid
7.	0.402	Valid	22.	0.002	Invalid
8.	0.452	Valid	23.	0.039	Invalid
9.	0.446	Valid	24.	-0.180	Invalid
10.	0.445	Valid	25.	0.403	Valid
11.	0.045	Invalid	26.	0.110	Invalid
12.	0.424	Valid	27.	-0.290	Invalid
13.	0.440	Valid	28.	0.461	Valid
14.	0.397	Valid	29.	0.144	Invalid
15.	0.418	Valid	30.	0.035	Invalid

Tabel 5. Recapitulation of Validity Item

Category	Item total	Percentage (%)
Valid	19	63.3
Invalid	11	36.7

Based on these calculations, the data obtained in this HOTS instrument has 19 items (63.3%) that are declared valid and 11 items (36.7%) that are declared invalid. "Valid" items mean that they can measure accurately, while "invalid" items mean that they cannot measure accurately (Sugiyono, 2014). The factor that makes items invalid is because the items have biased properties, which the questions cannot distinguish the abilities of students, between high and low (Oktanin & Sukirno, 2015).

Reliability of Instrument

The reliability of an instrument shows a level of consistency in making measurements (Rahmi, et al., 2021). The instrument can be said reliable if the instrument was tested shows the same or consistent results, even though it was implemented in different times and conditions. The way to find out the instrument that has been developed is reliable or not, the reliability test can be conducted by analyzing the data from one test. The calculation method was customized by looking the type of instrument that has been made. When HOTS instrument is a multiple-choice with one corrects answer, and the instrument cannot be ensured that have same level of difficulty, the HOTS instrument was analyzed by using KR-20 formula (Fraenkel, Wallen, & Hyun, 2012). The results of this calculation were interpreted into table of reliability degree according to Arikunto (2016) as follows.

Table 6. Reliability Degree

Value	Description
$0.00 < r_i \leq 0.20$	Very Low Degree
$0.20 < r_i \leq 0.40$	Low Degree
$0.40 < r_i \leq 0.60$	Good Enough Degree
$0.60 < r_i \leq 0.80$	High Degree
$0.80 < r_i \leq 1.00$	Very High Degree

The results of Excel calculations using the KR-20 formula obtained that instrument reliability value is 0.79. When interpreted into table of Reliability degree according to Arikunto (2016), the HOTS instrument on temperature and heat material is categorized as "High Degree" of reliability. According to Fraenkel, Wallen, & Hyun (2012) an instrument can be said to be reliable if the KR coefficient value is more than 0.70 ($ri > 0.70$). According to this result, it can be said that the instrument has been developed is Reliable.

Conclusion

Based on the results, the HOTS-based instruments on temperature and heat material can be concluded that the quality of HOTS based question instrument is feasible to use. It shown from level of difficulty that the instrument is in good category, the distinguishing power has value 0.66 with a good category, the validity of instrument obtained 19 items (63.3%) were declared valid and 11 items (36.7%) were declared invalid and the reliability obtained an r-count value is 0.78 which have "High Degree" category.

Author Contributions

Riski Dwi Fanani as conceptualization of this research includes research ideas, develop of HOTS based question instrument, data analysis, coordination with school, etc. Z.A.I Supardi and Nadi Suprapto as lectures who validated the HOTS question instrument and article review.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper

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