Analysis of High-Order Thinking Skills of High School Students in Solving Problems Related to Temperature and Heat

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Abstract - Higher Order Thinking Skills are abilities that students must have in facing the challenges of the industrial revolution era 4.0 because higher order thinking skills are complex thinking processes that involve conscious activities that will later be taken an action. The purpose of this study was to analyze higher order thinking skills of 11th grades in senior high school in Jember. The method used is a qualitative descriptive method with data collection techniques for temperature and heat test result based on higher order thinking skills and interviews. The result of this study, students have the ability to analyze 48.5%, evaluate 41%, and creation 39.5%. The conclusion of the research is students are in the moderate category in analyze and evaluate aspect, low category in the create aspect, it means students able to formulate the completion stage but are less able to combine information to produce the correct answer.

Keywords: Higher Order Thinking Skills; Temperature and Heat

INTRODUCTION

Education is a conscious and planned effort to develop students' potential, manifested in the learning process and learning environment (Akrim, 2021). Education quality serves as one indicator of a nation's progress (Tanujaya et al., 2017). With the presence of education in an individual's life, it becomes more directed and improved (Handriani et al., 2015). According to the Programme for International Student Assessment (PISA) 2018 survey results published in 2019, highlighting the quality of education in Indonesia in the categories of reading, science, and mathematics, Indonesia ranked 74th out of 79 countries. Data published by The Organisation for Economic Cooperation and Development (OECD) from 2009 to 2015 consistently placed Indonesia in the bottom 10 in all three categories. The implemented curriculum is the leading cause of Indonesia's low ranking (Sidu, 2020). The survey results from the Trends in

International Mathematics and Science Study conducted by the Global Institute indicate that only 5% of Indonesian students can solve high-level reasoning questions (Asri, 2017). High-level reasoning questions are those that require analytical thinking, evaluation, and creation, as outlined in Benjamin S. Bloom's cognitive taxonomy in the C4 (analyze), C5 (evaluate), and C6 (create) domains.

Currently, Indonesia has entered the fourth industrial revolution era, where humans have discovered new patterns through rapid technological advancements, such as the engineering of Artificial Intelligence and the Internet of Things (Diana et al., 2020). It demands that the education system in Indonesia keeps pace with the developments of the fourth industrial revolution. The first requirement to face the advancements in science and technology in this millennium is high-level thinking skills (Firdaus et al., 2022). The rapid development of knowledge and

technology in this era requires an emphasis on developing highly skilled and qualified human resources to compete in globalization (Erfan & Ratu, 2018). One effort made by the Ministry of Education and Culture (Kemendikbud) is the revision of the 2013 curriculum, known as the 2013 Revised Curriculum, which aims to cultivate high-level thinking skills in students to solve problems and face the increasingly sophisticated advancements of the times (Liyandri, 2021). High-level thinking skills involve a process beyond mere memorization but also require the ability to connect, analyze, draw conclusions, build representations, and transform knowledge and experiences to solve problems accurately and systematically (Baralemba, 2019). Students aged 15-19 represent the productive population that will contribute to a country's progress, leadership, and economic growth in the next 10 to 20 years (Falikhah, 2017). It can already be observed starting from the present. For example, the ability of students to solve problems may vary between male and female students, as problem-solving strategies can be influenced by gender differences (Paramita, 2014). The ability to solve problems is related to students' high-level thinking skills. Walfajri and Harjono (2019) state that students' high-level thinking skills impact their learning outcomes.

In order to assess students' learning outcomes, assessment is necessary (Ardiana & Sudarmin, 2015). Assessment is a method in the context of learning that identifies what has been known and what has not been known, as well as what students are capable of doing (Sumintono & Widhiarso, 2015). In this study, assessment is conducted by providing physics questions related to temperature and heat based on Higher Order Thinking Skills (HOTS) in essays to analyze the extent of students' abilities, including all

genders, male-only and female-only. The reason for conducting gender-based assessment is that gender has two aspects, namely gender identity and gender roles. Gender identity encompasses how individuals think about what should be done as a male or female according to norms and culture. Gender roles encompass how individuals think about their gender (Antasari, 2021). These two gender aspects will influence their way of thinking. The reason for using questions about temperature and heat is because they are natural phenomena and concepts that frequently occur in everyday life (Winarti & Budiarti, 2020).

Similar research has been conducted by Ramadhan et al. (2018); however, their study needed to analyze the abilities based on high-level thinking indicators. Therefore, the researcher conducted a new study with a different method to determine if the results would be the same or different and to provide additional analysis of students' high-level thinking abilities for a more comprehensive understanding.

Thus, this study aims to assess the abilities of students of all genders and the abilities of students within each gender based on the standards set by the International Center for the Assessment of Higher Order Thinking Skills. The data obtained from this study can serve as a reference for developing more targeted learning strategies and improving the quality of education to prepare a nation for future progress better.

RESEARCH METHODS

The research design used in this study to analyze high-level thinking abilities is survey research, while the research method employed is descriptive with a quantitative approach (Ariansyah et al., 2019). The sampling technique used is purposive

sampling. The research subjects consist of 32 students from one of the science classes (Class 11) in a high school in Jember. The instrument used is a set of 10 essay questions on physics related to temperature and heat based on Higher Order Thinking Skills (HOTS), which will serve as the primary data, supplemented by interviews as supporting data. In this study, a research procedure is established to facilitate the completion of the research.

The research procedure consists of three stages: (1) the Preparation stage, which includes conducting a pre-research visit to the chosen school, collecting data from literature sources related to temperature and heat, and designing the research to facilitate the study; (2) Implementation stage, which involves testing the validation of the research instrument by validators until it is deemed valid, collecting data through students' answer sheets from completing the questions and gathering data from interviews; (3) Final stage, which involves assessing and scoring the responses based on an assessment rubric, analyzing the assessment data and interview results, and drawing conclusions based on the data analysis.

Table 1. HOTS Category based on *International Center for the assesment of Higher Order Thinking Skills*

Score	Category
81-100	Excellent
61-80	Good
41-60	Moderate
21-40	Low
0-20	Very Low

The data analysis consists of two types: primary data analysis and supporting data analysis. The primary data analysis involves analyzing the high-level thinking abilities obtained by students from the test results, which are categorized according to the International Center for the Assessment of Higher Order Thinking Skills, as presented in Table 1. The supporting data, which includes the interview results, will be presented in a descriptive form and used to conclude.

RESULTS AND DISCUSSION
Results

The achievement of high-level thinking abilities of students from one of the senior high schools in Jember Regency, based on scores obtained from the temperature and heat test using Higher Order Thinking Skills (HOTS), can be observed in Figure 1.
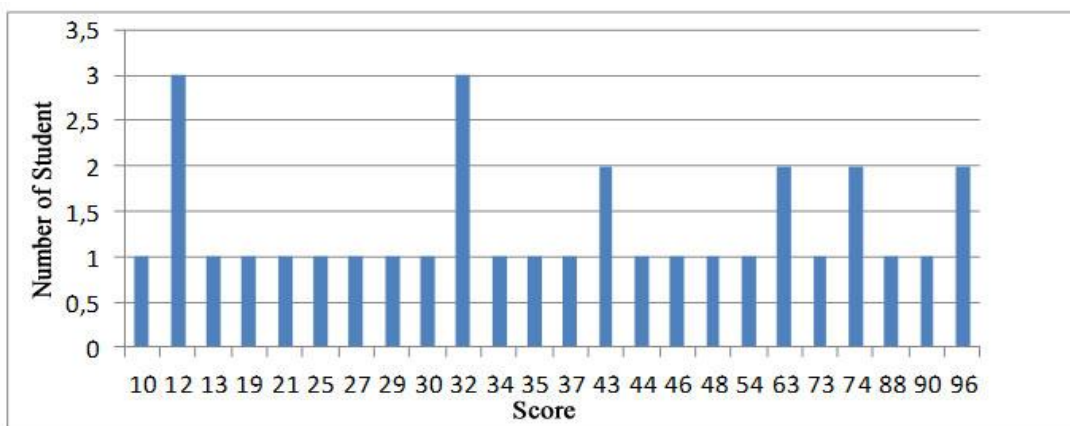

Figure 1. Graph of Scores Achievement for Temperature and Heat Test Based on HOTS (Higher Order Thinking Skills)

According to the International Center For The Assessment Of Higher Order Thinking

Skills, the average score obtained from the HOTS-based temperature and heat test is in

the moderate category. The number of students who occupy each category in higher-order thinking can be seen in Table 2.

Table 2. Analysis of Test Results for All Students

Category	Number of Student	Percentage
Very Good	4	12,5%
Good	5	15,6%
Moderate	6	18,75%
Low	11	34,4%
Very Low	6	18,75%

In addition, this study also analyzed students' higher-order thinking skills based on indicators of higher-order thinking in the cognitive domain covering three aspects, namely analyzing aspects, evaluating aspects, and creating aspects, the results of which can be seen in Table 3.

Table 3. Analysis of All Students' Abilities Based on HOTS Indicators

Indicators	Percentage
analyzing	48,5%
evaluating	41%
creating	39,5%

In this study, higher-order thinking skills were also analyzed based on gender, namely the higher-order thinking skills of students of male gender and the abilities of students of female gender, which will be seen as the difference. To see the scores obtained by male and female students can be seen in Figure 2.
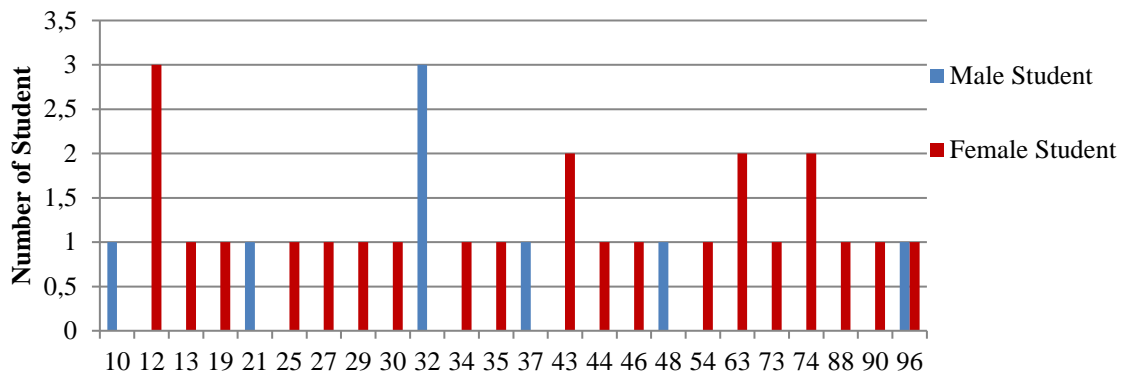

Figure 2. Graph of Scores Achievement for Temperature and Heat Test Based on HOTS Between Male and Female Students

The average score obtained from the HOTS-based heat and temperature test, according to the International Center for the Assessment of Higher Order Thinking Skills for male students, is in the low category, while for female students, it is in a moderate category. The difference between male and female students who occupy each category in higher-order thinking can be seen in Table 4.

Tabel 4. Analysis of Test Results Data Between Male and Female Students

Male Student			Female Student		
Category	Number of Student	Percentage	Category	Number of Student	Percentage
Very Good	1	12,5%	Very Good	3	12,5%
Good	0	0%	Good	5	20,8%
Moderate	1	12,5%	Moderate	5	20,8%
Low	5	62,5%	Low	6	25%
Very Low	1	12,5%	Very Low	5	20,8%

In addition, this study also analyzed higher-order thinking skills between male and female students based on indicators of higher-order thinking in the cognitive domain covering three aspects, namely analyzing aspects, evaluating aspects, and creating aspects, the results of which can be seen in table 5.

Table 5. Analysis of Abilities Between Male and Female Students Based on HOTS Indicators

Male Student		Female Student	
Indicators	Percentage	Indicators	Percentage
analyzing	43%	analyzing	50,3%
evaluating	33,8%	evaluating	43%
creating	33%	creating	41,5%

Discussion

In addition to the temperature and heat test scores based on Higher Order Thinking Skills (HOTS) as the primary data, this research also utilized interview data as supporting information. Interviews were conducted with selected students to understand the step-by-step problem-solving approaches.

Based on the data obtained from the temperature and heat test scores using Higher Order Thinking Skills, the results indicate that 12.5% of students have an excellent thinking ability, 15.6% have a good ability, 18.75% have a moderate ability, 34.4% have a low ability, and 18.75% have a very low ability. Students with an "excellent" category obtained scores ranging from 88 to 96. Students with a "good" category obtained scores ranging from 63 to 74. Students with a "moderate" category obtained scores ranging from 43 to 54. Students with a "low" category obtained scores ranging from 21 to 37. Students with a "very low" category obtained scores ranging from 10 to 19. The average score obtained by students is 44, categorized as

"moderate" according to the International Center For Assessment of Higher Order Thinking Skills. Comparing these results to a study conducted by Ramadhan et al. (2018) on high-order thinking skills using a two-tier multiple-choice instrument on quantum concepts and phenomena in high school students, there are differences in the data. In Ramadhan et al.'s study, no students had a "very high" thinking ability, whereas, in the present study, some students were categorized as having a "very high" thinking ability. These differences may be attributed to factors such as the media used (the present study utilized an essay-based HOTS instrument, while Ramadhan et al. used a two-tier multiple-choice instrument) and the topics covered (the present study focused on temperature and heat, while Ramadhan et al. focused on quantum phenomena). Additionally, the present study was conducted during the COVID-19 pandemic, which limited face-to-face interactions and only allowed 50% of students in a class to attend school, unlike Ramadhan et al.'s study conducted before the pandemic. These factors could have influenced the different results obtained, including the range of scores and the diversity of student abilities.

This research also measured students' abilities in specific aspects of high-level thinking, namely analyzing, evaluating, and creating. The results show that 48% of students are categorized as "moderate" in analyzing, indicating their ability to break down information into smaller parts to understand correlations. In evaluation, 41% of students are categorized as "moderate," showing their ability to assess ideas. Lastly, in creating, 39.5% of students are categorized as "low," indicating their limited ability to draw general conclusions from an idea or perspective. Analyzing has the highest percentage of student abilities, followed by evaluating and creating. These

findings align with a study conducted by Ratnasari et al. (2021) on high-level thinking skills in physics among high school students, which found similar results.

Furthermore, this research examines the differences in high-level thinking abilities between male and female students. In the "excellent" category, male and female students have the same percentage, 12.5%. In the "good" category, male students have a 0% percentage, while female students have a 20.8% percentage. In the "moderate" category, male students have a 12.5% percentage, while female students have a 20.8% percentage. In the "low" category, male students have a 62.5% percentage, while female students have a 25% percentage. In the "very low" category, male students have a 12.5% percentage, while female students have a 20.8% percentage.

Regarding high-level thinking, including analyzing, evaluating, and creating, female students outperform male students in all aspects. Male students score 43% in analyzing, while female students score 50.3%. In evaluation, male students score 33.8%, while female students score 43%. Male students score 33% in creating, while female students score 41.5%. The average scores for male students fall in the "low" category, while the average scores for female students fall in the "moderate" category.

Consequently, there is a significant difference in high-level thinking abilities between male and female students, with female students demonstrating higher abilities than males. These findings align with a study conducted by Sugiharto et al. (2021) on critical thinking skills in male and female high school students in the science program. According to Maccoby (cited in Anggoro, 2016), females have higher verbal abilities than males, while males have higher visual-spatial and mathematical abilities

than females. However, the research results show that female students outperform male students in test scores. It may be due to the detailed steps taken by female students in solving problems, such as writing down the steps, concepts used, reasons for choosing those concepts, known information, questions, using the correct formulas, and drawing appropriate conclusions. It demonstrates that female students are more diligent, motivated, and attentive, leading to higher test scores than male students. These findings are supported by previous research conducted by Zubaidah (2013), which explains that female students have a more diligent learning attitude compared to male students, and research conducted by (Antasari, 2021), which explains that female students are more careful, diligent, and accurate in solving problems and obtaining correct results. The interview data also indicates that both male and female students approached the problems to the best of their abilities.

CONCLUSION

Based on the results of the physics problem solving on temperature and heat based on Higher Order Thinking Skills (HOTS), the average score obtained by all sampled students according to the International Center for the Assessment of Higher Order Thinking Skills falls into the category of "sufficient." In terms of analyzing, students have a 48.5% proficiency level (sufficient category); in terms of evaluating, they have a 41% proficiency level (sufficient category); and in terms of creating, they have a 39.5% proficiency level (insufficient category). Male students are in the insufficient category. In terms of analyzing, male students have a 43% proficiency level (sufficient category); in terms of evaluating, they have a 33.8% proficiency level

(insufficient category); and in terms of creating, they have a 33% proficiency level (insufficient category). Female students are in the sufficient category. In terms of analyzing, female students have a 50.3% proficiency level (sufficient category); in terms of evaluating, they have a 43% proficiency level (sufficient category); and in terms of creating, female students have a 41.5% proficiency level (sufficient category). The interview data obtained aligns with the assessment results. In the higher-order thinking indicators, female students outperform male students and the highest aspect mastered by students is analyzing, while the lowest aspect is creating. Several recommendations to address this issue include providing more training in higher-order thinking skills by giving HOTS-based questions to both male and female students. Teachers should also motivate students more frequently to foster their enthusiasm in the learning process. Future researchers can try using different questions, methods, and durations to determine which approaches are more effective in analyzing students' higher-order thinking skills.

REFERENCES

Akrim. (2021). *Strategi Peningkatan Daya Minat Belajar Siswa*. Yogyakarta: Pustaka Ilmu.

Anggoro, B.S. (2016). Analisis Presepsi Siswa SMP Terhadap Pembelajaran Matematika Ditinjau Dari Perbedaan Gender Dan Disposisi Berpikir Kreatif Matematika. *Jurnal Pendidikan Matematika*, 7(2): 153 - 166. DOI: https://doi.org/10.24042/ajpm.v7i2.30

Antasari, B.I. (2021). Inovasi Teknologi Dan Produk Penelitian Pengabdian Masyarakat Berbasis Revolusi Industri 4.0 Di Era New Normal. *Prosiding Seminar Nasional Multidisiplin Ilmu*, Universitas Jabal Ghafur, 1-8.

Ardiana, M dan Sukarmin. (2015). Penerapan Self Assesment Untuk Menganalisis Kemampuan Berpikir Tingkat Tinggi Siswa. *Jurnal Pendidikan Kimia*, 9(1): 1459-1467. DOI: https://doi.org/10.15294/jipk.v9i1.4813

Ariansyah., Sahala, S., dan S.B Arsyid. (2019). Analisis Kemampuan Menyelesaikan Soal HOTS Fisika Materi Getaran Harmonik Di SMA Kristen Immanuel Pontianak. *Jurnal Pendidikan Dan Pembelajaran Khatulistiwa*, 8(6): 1-8.

Asri, M. (2017). Dinamika Kurikulum di Indonesia. *Jurnal Program Studi PGMI*, 4(2): 192-202.

Baralemba, A.M. 2019. *Cara Termudah Memahami, Melaksanakan, Serta Menulis Laporan dan Artikel Penelitian Tindakan Kelas*. Yogyakarta: Deepublish.

Diana, R., Mori, R.P., dan N. Mailani. (2020). Pendidikan Karakter Berbasis Multiple Intelligence Sebagai Desain Pembelajaran Di Era Disrupsi. *Prosiding Konferensi Pendidikan Nasional "Strategi dan Implementasi Pendidikan Karakter Pada Era Revolusi Industri 4.0"*, Universitas Islam Negeri Malik Ibrahim, 232-237.

Erfan, M, & T. Ratu. (2018). Pencapaian HOTS (*Higher Order Thinking Skills*) Mahasiswa Program Studi Pendidikan Fisika FKIP Universitas SAMAWA. *Jurnal Pendidikan Fisika dan Teknologi*, 8(2): 208-212.

Falikhah, N. (2017). Bonus Demografi Peluang Dan Tantangan bagi

Indonesia. *Jurnal Ilmu Dakwah*, 16(32).

Firdaus, M.W., Ugan, S., Diah, M., & M.M Chusni. (2022). Analysis of Students' High Order Thinking Skillsin Vertical MotionConcept. *Jurnal Pendidikan Fisika dan Teknologi*, 8(2): 276-281.

Handriani, L.S., A. Harjono, & A. Doyan. (2015). Pengaruh Model Pembelajaran Inkuiri Terstruktur dengan Pendekatan Saintifik terhadap Kemampuan Berpikir Kritis dan Hasil Belajar Siswa. *Jurnal Pendidikan Fisika dan Teknologi*, 8(2): 210-220.

Kemendikbud. (2017). *Panduan Implementasi Kecakapan Abad 21 Kurikulum 2013 di Sekolah Menengah Atas*. Jakarta: Direktorat Pembinaan SMA Ditjen Pendidikan Dasar dan Menengah.

Liyandri, V.A. (2021). Analisis Kemampuan Berpikir Tingkat Tinggi Siswa SMA Dalam Menyelesaikan Permasalahan Kombinatorika. *Skripsi*. Jember: Fakultas Keguruan dan Ilmu Pendidikan.

Paramita, M. (2014). *Kota Layak Anak Indonesia*. Yogyakarta: Hunian rakyat Caritra Yogya.

Sidu. (2020). Hasil Survei PISA Tentang Kualitas Pendidikan di Indonesia Dalam 3 Tahun Terakhir. https://ayomenulis.id/artikel/ini-dia-hasil-survei-pisa-tentang-kualitas-pendidikan-di-indonesia-dalam-3-tahun-terakhir. [Diakses pada 18 September 2021].

Sugiharto, B., Azizzah, H., Arafa, M., Prima, N., & Alifah, N. (2021). Keterampilan Berpikir Kritis Siswa SMA Laki-Laki dan Perempuan Pada Program IPA. *Phenomenon: Jurnal Pendidikan MIPA, 11*(2), 157-168.

doi:https://doi.org/10.21580/phen.2021.11.2.4921

Sumintono dan Widhiarso. 2015. *Aplikasi Pemodelan RASCH Pada assessment Pendidikan*. Cimahi: Trim Komunikata.

Ramadhan G., Dwijananti, dan S. Wahyuni. (2018). Analisis Kemampuan Berpikir Tingkat Tinggi (High Order Thinking Skills) Menggunakan Instrumen Two Tier Multiple Choice Materi Konsep dan Fenomena Kuantum Siswa SMA di Kabupaten Cilacap. *Unnes Physics Education Journal*, 7(3): 86-90.

Ratnasari., Haris, A., dan A. Azis. (2021). Studi Kemampuan Berpikir Tingkat Tinggi Fisika Di SMA. *Jurnal Sains dan Pendidikan Fisika*, 17(1): 57-68.

Tanujaya, B., J. Mumu, & G. Margono. (2017). The Relationship between Higher Order Thinking Skills And Academic Performance of Student in Mathematic Intruction. *International Education Studies*, 10(11): 78-85.

Walfajri, R.U. & N. Harjono. (2019). Peningkatan Kemampuan Berpikir Kritis Dan Hasil Belajar Tematik Muatan IPA Melalui Model Problem Based Learning Kelas 5 SD. *Jurnal Basicedu*, 3(1): 16-20.

Winarti, W, dan I.S. Budiarti. (2020). Diagnosis Konsepsi Siswa Pada Materi Suhu Dan kalor. *Jurnal Ilmu Pendidikan Indonesia*, 8(3): 136-146.

Zubaidah. (2013). Perspektif Gender Dalam Pembelajaran Matematika. *Jurnal Perempuan, Agama, Dan Gender*. 12(1): 15-31.