Analysis of students' ability in completing HOTS-based Basic Physics questions

A Halim\textsuperscript{1,3,*}, I Mastura\textsuperscript{1}, Soewarno\textsuperscript{1}, Elisa\textsuperscript{1}, E Mahzum \textsuperscript{1}, A Farhan\textsuperscript{1} and I Irwandi\textsuperscript{2,3}

\textsuperscript{1} Department of Physic Education, Training Teacher and Education Faculty, Universitas Syiah Kuala, Banda Aceh, Indonesia 23111
\textsuperscript{2} Department of Physic, Faculty of Science and Mathematics, Universitas Syiah Kuala, Banda Aceh, Indonesia 23111
\textsuperscript{3} The STEM Centre of Integrated Laboratory, Universitas Syiah Kuala, Banda Aceh, Indonesia 23111

*E-mail: abdul.halim@unsyiah.ac.id

Abstract. This study aims to determine students' higher order thinking skills in solving HOTS-based Basic Physics questions. The research method used is descriptive method with a quantitative approach. The research subjects were 23 students of the second semester of the Physics Education Study Program. The data collection technique used was a test by giving questions consisting of three questions covering questions to analyse, evaluate and create. Based on the results of data analysis, it is known that students' high-order thinking skills in solving HOTS-based Basic Physics questions are in the poor category with the following details: The percentage of students who have high-order thinking skills is very good category is 15%, good category is 10%, category 25% enough, 35% less category and 15% very poor category. The inference from these results is that in the evaluation of the Basic Physics subject, it is necessary to add more high-level standard questions.

1. Introduction
The ability of students to solve problems in everyday life is the main target of an educational institution. Each graduated is expected to be able to analyse and make decisions or policies on every problem it faces, especially the problem of global economic competition without ethnic, national, and state boundaries [1]. Therefore, every educational institution needs to think about curriculum design, teaching strategies and evaluation of learning that leads to decision-making or real problem solving. Lecturers, teachers, or other education personnel are very important components as field curriculum implementers who face directly with students or students. Lecturers, as professionals and scientists have the duty and responsibility to transform, develop, and disseminate science, technology, and art through education, research, and community service [2]. Related to research and development of problem-solving oriented learning strategies, many studies have been conducted by researchers or lecturers. Among them, are problem solving exercises through community technology science strategies [3], media tracker [4], arguments or reasons [5], solving high-order thinking types [6, 7], solving various types of problems in mathematics [8, 9, 10, 11] and through problem-based learning [12,13].

Although various types and methods of learning have been carried out to improve problem-solving abilities, there are still many alumni of educational institutions who are not ready to compete in the
world of work or are unable to compete with alumni of overseas educational institutions [1, 14, 15]. One of the factors causing the problem-solving ability is still low is that students are not trained to complete tests or questions that require or require analysis, evaluation and high creativity or questions that require high-order thinking skills or HOTS [16]. According to the revised version of Bloom's taxonomy it is said that cognitive processes are divided into two groups, namely high-order thinking skills or HOTS, and low-level thinking skills or LOTS [17]. Low-level thinking skills involve the ability to remember (C1), understand (C2), and apply (C3), while high-order thinking skills include analysis and synthesis (C4), evaluate (C5) and create or creativity (C6) [18].

Various fields of science have developed questions based on higher order thinking skills (HOTS), including questions in biology [19, 20, 21], problems in chemistry [22], questions in mathematics [23, 24, 25, 26], and problems in physics [27, 28, 29, 30, 31, 32]. HOTS-based physics problems have been developed on the concept of fluid [29], harmonic vibration [30], quantum physics [31], impulse and momentum [32], and temperature and heat [33]. The impact of several studies on the student's ability to solve HOTS-based questions was still low, especially on C4 and C5 questions with the average student score in solving C4 questions of 53.18, C5 questions of 52.27, while C6 questions of 68.83 were in the category good [34]. Other researchers found that students' high-order thinking skills in solving optical questions were in the good category with 47.30% and the rest were in the sufficient and poor category [35]. Another study found that students' thinking skills in solving questions in the analysis, evaluation, and creation stages or around 12 students had high HOTS, 18 students had medium HOTS and 6 students had low HOTS.

Based on some of the research results that have been described above, it shows that studies to increase the ability of students to solve HOTS-based physics questions are being carried out. Other findings indicate that the ability of students to solve problems in physics lessons in the form of HOTS is relatively high, but not significant. This effort needs to be done continuously so that students are accustomed to and able to solve HOTS-shaped physics questions. Considering that, the references that have been obtained regarding the making of basic physics questions in the form of HOTS are minimal, the research output will add to the reference in the study.

2. Research Methods

2.1. Research Design
This research uses a quantitative approach and data collection through survey methods. The survey was conducted on students who were taking Basic Physics II courses. The survey used HOTS-based Basic Physics II questions with C4, C5, and C6 cognitive domains. The stages of this type of survey research are simply shown in Figure 1.

2.2. Population and Sample
The target population is all students (as many as 60 people in 3 classes A, B, and C) who are taking Basic Physics II courses in the physics education department of the Teaching and Education Faculty, Universitas Syiah Kuala, Banda Aceh. Sampling was taken by simple sampling and obtained as much as one local regular B or about 20 students.

2.3. Data Collection
Data collection used essay test instruments at the cognitive levels C4, C5 and C6 or in the form of high-order thinking skills (HOTS) containing content on Basic Physics II questions or specifically about dynamic electricity. Question indicators are adjusted to the II Basic Physics syllabus in Higher Education. Based on these indicators 3 HOTS questions were developed by researchers. The three description questions (Electromotive Force (EMF) Induction, Resistor Inductor and Capacitor (RLC) circuit, and Kirchoff’s Law) before being used are given to content experts and pedagogics for validation. After validation and consultation with the expert 3 times, the test instrument is ready to be distributed to 20 respondents as research samples.
2.4. **Data Analysis**

The data analysis was carried out in two stages. First, analyse student work results or answers from the answer sheets collected by students. The technique of analysing student answers is carried out using a standard reference standard with a scale of 100. At this stage, a profile of the student's ability for each student's answer is also carried out based on the C4, C5 and C6 domains. Second, quantitative data analysis was carried out using descriptive statistics, the aim was to obtain information about the final score of the test which would illustrate the student's ability to solve HOTS-based physics questions.

3. **Results and Discussion**

In accordance with the research objectives that have been formulated at the beginning of the article, the research data obtained are (i) The ability of students to solve dynamic electrical problems in the form of HOTS. (ii) The ability of students to solve dynamic electrical problems in the form of HOTS in terms of cognitive C4 (analysis), C5 (evaluation) and C6 (creation).

3.1. **Average Student’s Ability**

The results of the student ability test in answering dynamic electrical questions as a whole and according to the high, medium and low categories are shown in table 1. In table 1 the maximum value is 93.9 and the minimum value 7.5 is taken from the average value of the three questions from each students who have completed HOTS-based questions. Based on the data in Table 1, it is known that those who have a very good category are only 3 people or 15% with a value range of 81-100, either 2 people or 10% in either category, 5 people or 25% in sufficient category, 7 people or less in the category. 35%, and in the very poor category there are 3 people or 15%. In general, it can be said that about 25% of students were able to answer questions well, 25% of students were able to answer questions in the medium category and about 50% of students were still less able to answer dynamic electricity questions in the form of HOTS. Based on the average value obtained of 45.94 or still in the range of values that are not high or

![Flowchart of Research Process](chart.png)

**Figure 1.** Design of survey research [37].
it can be said that the average score of students in solving HOTS-based questions is in the sufficient category.

Table 1. The percentage of students' high-level thinking in solving HOTS questions [38].

| Score   | Categories     | Frequency | Percentage (%) | Distributed |
|---------|----------------|-----------|----------------|-------------|
| 81 – 100| Very Good      | 3         | 15%            | Max.Score : 93.9 |
| 61 – 80 | Good           | 2         | 10%            | Min.Score : 7.5 |
| 41 – 60 | Middle         | 5         | 25%            | Average : 46 |
| 21 – 40 | Less           | 7         | 35%            |             |
| 0 – 20  | Very less      | 3         | 15%            |             |
| Sum     |                | 20        | 100%           |             |

Based on the results of data processing and data analysis above, it is known that the ability of students to solve Basic Physics II questions based on HOTS is still in the sufficient and inadequate category, or in other words, the high level thinking skills of students at Department of physics education, Training Teacher and Education Faculty, Universitas Syiah Kuala are still lacking. Among the contributing factors are students who work on questions in unhealthy conditions, the ability to think at higher levels is not sharpened when they are still in school and students do not get teaching methods that lead to developing higher order thinking patterns. This finding is in line with the study conducted by Nurhayati [35] and Agung [36], both found that the students' ability to solve HOTS-based physics questions was still at an adequate stage. While the causal factors according to several previous studies were due to the students' incompleteness in the process of solving the questions, and the students' low initial mathematical abilities [37]. Beside that the process that was passed during learning during lectures was not optimal, the students' lack of understanding of the questions, the incompleteness in reading questions and the lack of parental attention [38, 39].

Table 2. Profile of students' answers to cognitive questions C4, C5 and C6.

| No | Topic           | Max.Score | Min.Score | Average | Categories | Cog. |
|----|----------------|-----------|-----------|---------|------------|------|
| 1  | EMF Induction  | 85        | 5        | 51.1    | Enough     | C4   |
| 2  | RLC circuit    | 100       | 10       | 46.5    | Enough     | C5   |
| 3  | Kirchoff's Law | 100       | 4.4      | 40.3    | Less       | C6   |

3.2. Student’s Ability per Item

The test instrument used for data collection contained 3 items or for each cognitive domain there was one item or for domain C4 (analysis) item no.1, domain C5 (evaluation) item no 2, and domain C6 (creation) item no. 3. The topics of dynamic electricity, student answer profiles and categories of students' ability to solve HOTS-based questions according to the cognitive domain are shown in Table 2. Based on the data in table, it can be said that overall the highest average value per item is item 1 in the cognitive analysis domain (C4), then item 2 is in the cognitive evaluation domain (C5) and the lowest is item 3 with the domain of evaluation. In other words, students majoring in physics education, especially those taking Basic Physics II have very low creativity. However, the three aspects of high-level thinking skills (analysis, evaluation, and creation) are relatively low or still lack high-level thinking skills.
Figure 2. Profile of students' answers to the cognitive domains C4, C5 and C6.

The profile of the answers to the test results per student and per cognitive domain is shown in detail in Figure 2. The blue line is the answer to the C4 question in question compiled from the student who has the highest test result score to the student who has the lowest test result score. It turns out that from the answer sequence for items in domain C4, it is not followed by the results of answers from items in domain C5 and C6. This means that not all students who have high analytical cognitive skills are also high in the cognitive evaluation and creation domains, and vice versa. However, there are some students who have a high cognitive level and a high level of cognitive evaluation and creation. In other words, students at Department of physics education, training teacher and education faculty, Universitas Syiah Kuala have varied cognitive abilities, there are students who have high evaluation abilities, but low in analytical and creative abilities, but there are also students who have high creative abilities but low in the realm of evaluation and analysis.

The difference in student ability from the cognitive aspect is something that is logic and natural, this is because these abilities are influenced by reasoning power, the environment, learning media [41, 43], teachers [39], learning models [42] and learning facilities [40, 44]. There is also another view, which says that students who have high-order thinking power can achieve the creative aspect, while students who have moderate thinking power can achieve the creative aspect and express opinions, but cannot conclude. On the other hand, students who have low thinking power cannot achieve the aspect of creating and concluding [45].

Conclusion
Based on the results of data analysis and discussion with some of the previous results, it shows that the ability of students to solve high-grade physics problems or their solutions requires high-level thinking skills that are still low or in the sufficient category. There are several factors causing this, including the influence of the media, models, learning facilities, the environment, and the ability of teachers.

References
[1] Halim A, Yusrizal, Susanna and Tarmizi 2016 J. Pendidik. IPA Indone. 5 1–5
[2] Undang-Undang RI 2005 Undang-undang Guru dan Dosen No.14 Tahun 2015. (Jakarta: MENTERI HUKUM DAN HAK ASASI MANUSIA REPUBLIK INDONESIA)
[3] Maidan, Halim A, Safitri R and Nurfadilla E 2020 J. Phys. Conf. Ser. 1460 012145 1–7
[4] Wati S, Halim A and Mustafa 2020 J. Phys. Conf. Ser. 1460 1 1–6
[5] Miswanto A, Susanti E, Hapizah H, Meryansumayeka M and Nurzalena A 2019 Journal of Physics: Conference Series 1318 1
[6] Halim A, Ngadimin, Soewarno, Sabaruddin and Susanna A 2018 J. Phys. Conf. Ser. 1116 3
[7] Kusaeri K, Hamdani A S and Suprananto S 2019 *Infinity Journal* 8 75
[8] Rohimah S. M and Prabawanto S 2019 *International Journal of Trends in Mathematics Education Research* 2 34
[9] Leksmono A, Prihandoko A C and Murtikusuma R P 2019 *Journal of Physics: Conference Series* 1211 1
[10] Sandy W R, Inganah S and Jamil A F 2019 *Mathematics Education Journal* 3 72
[11] Ulfah H K and Fuad Y 2019 *Jurnal Ilmiah Pendidikan Matematika* 8 34
[12] Waluyo E M, Muchyidin A and Kusmanto H 2019 *Tadris Jurnal Keguruan dan Ilmu Tarbiyah* 4 27
[13] Anzelina D 2020 *Journal of Physics: Conference Series* 1538 1
[14] Pelekh Y 2020 *Problems of Education in the 21st Century* 78 671
[15] LPDP 2018 Laporan tahunan; Beasiswa Inklusif untuk Pendidikan Berkelanjutan [Annual report; Inclusive Scholarships for Continuing Education] (Jakarta:Lembaga Pengelola Dana Pendidikan)
[16] Dewi N R 2020 *Unnes Science Education Journal* 9 23
[17] Krathwohl D R 2002 *A revision of Bloom's Taxonomy: an overview – Theory into Practice* (College of Education, The Ohio State University)
[18] Krathwohl D R and Anderson L W 2001 *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives* (New York: Longman)
[19] Afandi A, Hidayat S and Syahri I 2019 *Jurnal Pendidikan Biologi Indonesia* 5 313
[20] Kamsurya R and Saputri V 2020 *Jurnal Ilmiah Mandala Education* 6 2
[21] Sari Y and Cahyaningtyas A P 2020 *Journal of Physics: Conference Series* 1517 1
[22] Widarti H R, Herunata H, Sulistina O, Habibdin H and Nadhifah Y 2020 *International Conference on Learning Innovation 2019* 21
[23] Njurumana N Y, Baidawi M and Rahayuningsih S 2020 *Mathematics Education Journal* 3 109
[24] Rahmawatininingrum A, Kusmayadi T A and Fitriana L 2019 *J. Phys.: Conf. Series* 1318 1
[25] Sridana N, Prayitno S and Baidowi B 2020 *1st Annual Conference on Education and Social Sciences 2019* 357
[26] Soewarno S, Herliana F and Musdar M 2020 *Asian Journal of Science Education* 2 71
[27] Merta D K, Rosidin U, Abdurrahman A and Suyatna A 2017 *IOSR Journal of Research & Method in Education* 7 26
[28] Akhsan H, Wiyono K, Ariska M and Melvany N E 2020 *J. Phys.: Conf. Ser.* 1467 1
[29] Zainuddin, Mujakir, Ibrahim M, Jatmiko B, Halim A and Yusrizal 2020 *J. Phys. Conf. Ser.* 1460 1
[30] Yusuf I, Widyaningsih S W and Sebayang S R B 2018 *Journal of Turkish Science Education* 15 67
[31] Eveline E, Suparno S, Ardiyati T K and Dasilva B E 2019 *Jurnal Penelitian & Pengembangan Pendidikan Fisika* 5 123
[32] Agung J and Sri Sutarni M P 2018 *Analysis of Higher Order Thinking Skills of Students in Solving Group Algebraic Structure Problems* (Doctoral dissertation, Universitas Muhammadiyah Surakarta)
[33] Fraenkel J R, Wallen N E and Hyun H H 2012 *How to Design and Evaluate Research in Education* (New York: McGraw-Hill)
[34] Prasetyani 2016 *Jurnal Gantang Pendidikan Matematika* 1 31
[35] Halim A, Yusrizal, Mazlina H, Melvina and Zainaton 2018 *J. Phys. Conf. Ser.* 1088 1
[36] Irwandi, Oktavia R, Rajbussalam, Halim A and Melvina 2018 *J. Phys. Conf. Ser.* 1088 1
[41] Halim A, Mahzum E, Zanaton and Humairah 2020 J. Phys. Conf. Ser. 1521 1
[42] Nurmalia, Halim A and Syahrun N 2020 J. Phys. Conf. Ser. 1460 1
[43] Junina I, Halim A and Mahidin 2020 J. Phys. Conf. Ser. 1460 1
[44] Arifullah, Halim A, Syukri M and Nurfadilla E 2020 J. Phys. Conf. Ser. 1460 1
[45] Heong, Mei and Yee 2011 Int. J. of Social Science and Humanity 1 121

Acknowledgements
To all those who have assisted in the research and writing of this article, we thank you very much. Especially to the managers of the Department of Physics Education, training teacher and education faculty, Universitas Syiah Kuala and MPIPA Postgraduate who have helped administration of research, we thank you. To the STEM Study Centre, the integrated Lab of Universitas Syiah Kuala - USAID who has helped finance the publication of articles, we would like to thank you.