

An Analysis of the 2019's National Physics Exam Questions Using the Taxonomy of Introductory Physics Problem

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Abstract - The study aims at describing the composition of the cognitive system in 2019's physics high school national exam questions. The theoretical framework applied in analysing the exam is Taxonomy of Introductory Physics Problem (TIPP). Then, this study applies a quantitative descriptive design by conducting document analysis for the aforementioned exam, which consists of 40 item questions. Interestingly, the findings indicate that the analysed questions have been designed based on the TIPP principles, which include the categories of remembering, understanding, analysing, and applying knowledge with 3, 2, 15, and 20 questions respectively. This indicates that the questions for each category are not evenly distributed as the categories of remembering and understanding have fewer number of questions compared to others. Such evidence can actually be an essential insight for the national exam question development team in considering the portion comparison of the question items for the four categories of TIPP.

Keywords: National Exams; Taxonomy of Introductory Physics Problem; TIPP

INTRODUCTION

To control and supervise the implementation of education in Indonesia, the government has issued eight Ministerial Regulations. One of them is the Regulation of the Minister of National Education Number 20 of 2007 dated June 11, 2007 on Educational Assessment Standards. The regulation states that educational assessment standards are national education standards concerning the mechanisms, procedures, and instruments for assessing student learning outcomes, and educational assessment is the process of collecting and processing information to determine the attainment of student learning outcomes (Sulistiawan, 2016).

Ningsih et.al. (2019) adds: assessment in education is a process of collecting and processing information to determine the attainment of learning outcomes from students. The assessment of the learning outcomes by the teacher uses various assessment techniques such as tests,

observations, individual or group assignments and other forms, based on the characteristics of the competence and the student's development level. Assessment needs to be conducted to measure the extent to which the competencies have been achieved by students in the learning process.

The assessment conducted by the teacher is a form of evaluation for the learning that has been conducted. According to Septiana (2016), for the purpose of evaluating the teaching and learning process, standardized tests can be used, as well as teacher-made tests. Standardized test is a test that has undergone a standardization process, namely the process of validity and reliability, so that the test is truly valid (legitimate) and reliable (steady) for a purpose and for certain groups. Standardized tests from the central government are used in national exams. Meanwhile, the teacher's own test is a test prepared by the teacher himself to evaluate the success of the teaching and learning process. Usually,

teacher-made tests are widely used in schools. This teacher-made test is usually limited to a class or to a school.

Andayani, et.al. (2019) adds: evaluation is an important stage in learning. Philosophically, the evaluation process is an important process which serves as one of the three anchors of education (i.e., objectives, methods and evaluation). One of the mandatory components in the evaluation is the test instrument.

Tests are generally used to assess and measure student learning outcomes, especially the cognitive learning outcomes concerning the mastery of teaching materials or materials that have been taught. The test is used as an assessment tool in education, in which it has an important role in measuring the achievement of student learning outcomes (Nurjannah, 2015).

The test model as an evaluation tool has been widely used by nations in the world as a tool for counselling, selecting and placing students (Gregory, 1992). In relation to the educational process at the pre-university level (high school level and below), the national-scale test model has undergone several changes and improvements. Chronologically, the development of the final exam is as follows: (a) from 1965 to 1971 it was called State Examination (b) from 1972 to 1979, it was called School Examination, (c) later on it was National Final Level Learning Evaluation (EBTANAS), and (d) from 2001 until now, it was called the National Final Examination (UAN) which was later changed to National Examination (Idrus, 2010).

The National Examination is an educational standard evaluation system conducted by the Education Assessment Centre based on the Law of the Republic of Indonesia number 20 of 2003 which states that in order to control the quality of

education nationally, evaluation is conducted as a form of accountability from education providers to stakeholders. According to Nurlailiyah, et.al (2019), the National Examination is the activity of measuring the attainment of graduate competencies in certain subjects in a national scale, on the basis of the Graduate Competency Standards.

Meanwhile, according to the Regulation of Minister of Education and Culture number 5 of 2015 article 1 paragraph 5, the National Examination, hereinafter referred to as the UN, is an activity of measuring and assessing the attainment of graduate competence in certain subjects in a national level. According to the Regulation of Minister of Education and Culture number 5 of 2015 article 21 paragraph 1, the results of the National Examination can be used: (1) to map the quality of programs and/or educational units; (2) as a determinant for the entrance selection of the next level of education; and (3) as consideration factor in supporting and providing assistance to educational units in the attempt to improve the quality of education (Ningsih, 2019).

Sulistiawan (2016) added: the National Examination (UN) aims at assessing the attainment of graduate competencies for certain subjects in the science and technology subject group, in a national scale. In the Law of the Republic of Indonesia Number 20 of 2003 Article 57 it is stated that in order to control the quality of education nationally, evaluation is conducted as a form of accountability for the implementation of education to the stakeholders. The National Examination is used as a government standard to test the feasibility of a student so that they are able to continue their education to a higher level and also, as an equal distribution of education nationally.

An issue that is often experienced by students when taking the national exam is regarding the difficulty in solving the UN questions. Based on the results of observations made to several students who have completed the national exam, many of them reasoned that the questions were difficult to solve because the level of the questions was considered different from that of the questions that they have gone through so far. In fact, some questions are considered novel to them.

Based on these reasons, the researcher assumed that this problem is rooted in the lack of students' practice in solving questions with the same level as the National Examination questions. In reality, as obtained in the field, the questions that are often practiced and answered are questions that are at memory-recalling level, solving the National Examination questions requires high-level thinking skills. Therefore, teachers as educators should be able to make their students familiar with answering questions that are at the same level as the National Examination. That is, in the evaluation process, teachers should prepare instruments that can accustom students to higher-order thinking.

The basic thing that must be recognized in making the instrument is the distribution of items representing the students' abilities, starting from basic to high level. As for questions for physics subject, a guideline that can be used to determine the distribution of the questions is the Taxonomy of Introductory Physics Problem (TIPP).

TIPP was first introduced by Teoderescu et al. (2013). TIPP is the result of research that refers to The New Taxonomy of educational Objective (NTEO) developed by Marzano and Kendall. TIPP has better characteristics for analyzing physics problems. The advantages of TIPP include

the placing of metacognitive processes under cognitive processes, the placing of the self system at the top of thinking process, a clear separation between affective, psychomotor and cognitive, the presence of problem solving and its arrangement from simple to complex things. This taxonomy consists of two dimensions that are contained in three systems (self-system, metacognitive system, and cognitive system) and one knowledge dimension. The knowledge domain includes information, mental procedures, and psychomotor procedures. The cognitive system is further divided into 4 levels, namely level 1: Retrieval., level 2: Comprehension, level 3: Analysis, level 4: Knowledge Utilization.

Angraeni, et.al (2020), added that the Taxonomy of Introductory Physics Problems (TIPP) is specially designed to classify physics problems. In TIPP, there are 4 levels of cognitive systems thinking that can cover critical thinking skills in solving problems, namely: Retrieval (recalling), Comprehension (understanding), Analysis, Knowledge Utilization (the use of knowledge). This shows that TIPP can practice problem solving skills which are arranged in a hierarchy of simple (remembering) to complex things. Meanwhile, Hanakova, et.al (2016) explained that The Taxonomy of Introductory Physics Problems (TIPP) is a classification of physics problems in the context of introductory physics material. It involves a database containing text-based and research-based physics problems, which describe their relationship to cognitive processes and knowledge.

In regards to the problems that have been presented; it is deemed necessary to conduct research on the analysis of Physics National Examination questions using TIPP. The aim is to find out how the levels of each question in the Physics National

Examination is distributed based on TIPP, so that it serves as an insight for the teachers in accustoming their students to high-level questions.

RESEARCH METHODS

This research is descriptive quantitative. This study uses 2019’s Physics National Examination questions, which consists of 40 multiple-choice questions with a 5 options for answer, namely a, b, c, d, and e. The UN questions are obtained from <https://www.phiradio.net>. This research is only limited to the analysis of the distribution of UN items that were adjusted to the cognitive level in the Taxonomy of Introductory Physics Problems (TIPP). For analysis purposes, one set of questions was chosen. This is due to the writers of the UN questions’ guarantee that each set of questions has the same ‘weight’ based on the Graduation Competency Standards (SKL) that have been constructed nationally.

Each question is analyzed and adjusted to the level of Taxonomy of Introductory Physics Problems. The analysis with TIPP will make reference to the taxonomy created by Teoderescu et al (2013) which is the result of research that refers to The New Taxonomy of educational Objective (NTEO) developed by Marzano and Kendall.

The TIPP cognitive system is divided into 4 levels, namely level 1: Retrieval., level 2: Comprehension, level 3: Analysis, level 4: Knowledge Utilization.

RESULTS AND DISCUSSION

Results

Based on the results of the analysis of the 2019 Physics UN items using the Taxonomy of Introductory Physics Problems, it was discovered that the distribution of questions in accordance to the TIPP category is as shown in Table 1.

Table 1. The results of the analysis for 2019 UN’s Physics questions using TIPP (the Distribution of UN Physics questions based on TIPP)

Level.	Category	Subcategory	Question number	Frequency	Percentage
1	<i>Retrieval</i>	a) <i>Recalling and recognizing</i>	16, 38	2	7%
		b) <i>Executing</i>	34	1	
2	<i>Comprehension</i>	a) <i>Integrating</i>	32, 33	2	5%
		b) <i>Symbolizing</i>	-	-	
3	<i>Analysis</i>	a) <i>Matching</i>	7, 15, 17, 22, 27	5	38%
		b) <i>Classifying</i>	10, 25	2	
		c) <i>Analyzing errors</i>	26, 29, 36	3	
		d) <i>Generalizing</i>	8, 28, 40	3	
		e) <i>Specifying</i>	5, 21	2	
4	<i>Knowledge utilization</i>	a) <i>Decision making</i>	-	-	50%
		b) <i>Overcoming obstacles (problem solving)</i>	2, 3, 6, 9, 11, 12, 14, 19, 20, 23, 30, 35, 37, 39	14	
		c) <i>Experimenting</i>	1, 24	2	
		d) <i>Investigating</i>	4, 13, 18, 31	4	

Based on table 1, information related to the distribution of UN’s Physics questions using TIPP was obtained. Level 1a: recalling and recognizing is found in questions number 16 (subchapter: wave) and 38

(subchapter: core physics). At this level, students are required to be able to recognize basic physics knowledge related to the problem of the nature of light wave and recognize the use of radioisotopes. Level 1b:

executing is found in question number 34 (subchapter direct current electricity), whereby the students are required to be able to measure the strength of the current.

Level 2a: integrating is found in questions number 32 (static electricity - capacitors) and 33 (static electricity - electric field strength). Students are required to be able to identify the arrangement of capacitors in an electric circuit and determine the magnitude of the electric field strength of the particles. Level 2b: symbolizing is not found in the 2019 UN's Physics questions.

Level 3a: matching is found in questions number 7, 15, 17, 22, and 27. These questions require students to have the ability to identify by matching the materials for subchapter kinematics, spring arrangements (elasticity), waves on water (waves), image formation on a mirror (geometric optics), an ideal gas (kinetic theory of gases).

Level 3b: classifying is found in question number 10, which consists of the material for collision subchapter (impulse momentum) and number 25 which consists of the material for conductivity subchapter (temperature and heat). At this level, students are required to be able to classify inelastic collisions on balls and classify the appropriate types of glass based on the theory of conductivity.

Level 3c: analyzing errors is found in questions number 26 (ideal gases - kinetic theory of gases), 29 (radiation - electromagnetic waves), and 36 (RLC circuit - alternating current). At this level, students are required to be able to make reasonable assumptions and estimates on the properties of a monatomic ideal gas, the dangers of ultraviolet light for life, and the RLC circuit system.

Level 3d: generalizing is found in question numbers 8 (subchapter of parabolic

motion - kinematics), 28 (subchapter of thermodynamics - Carnot cycle), and 40 (subchapter of black body radiation). At this level, students are required to be able to build generalizations or new principles from existing knowledge.

Level 3e: Specifying is found in question number 5 about the subchapter of work & energy, as well as in question number 21 about the subchapter of light waves. At this level, students are required to be able to produce new applications or logical consequences of existing physics knowledge.

Level 4a: decision making was not found in any of the question. Level 4b: overcoming obstacles (problem solving) is found in question number 2 (kinematics - displacement), 3 (dynamics - Newton's second law), 6 (work and energy - mechanical energy), 9 (rotational motion - angular velocity) , 11 (dynamic fluid - aircraft wing), 12 (rotation - angular velocity), 14 (rigid bodies - center of gravity), 19 (sound waves), 20 (sound waves - Doppler effect), 23 (temperature & heat), 30 (nuclear physics), 35 (direct current electricity - Kirchoff analysis), 37 (electromagnetic induction - magnetic fields), and 39 (modern physics). At this level, students are required to be able to set goals or tasks that become obstacles or limiting conditions so that they can make decisions from various available options.

Level 4c: experimenting is found in question number 1 about measurement and question number 24 about temperature & heat. Students are required to be able to provide the right answers for questions that are presented in the form of the conduct of experiments. Level 4d: investigating is found in question number 4 (kinematics - circular motion), 13 (dynamics - friction), 18 (waves), and 31 (static electricity-Coulomb's law).

The comparison of the percentage of each level's occurrence is illustrated in Figure 1.

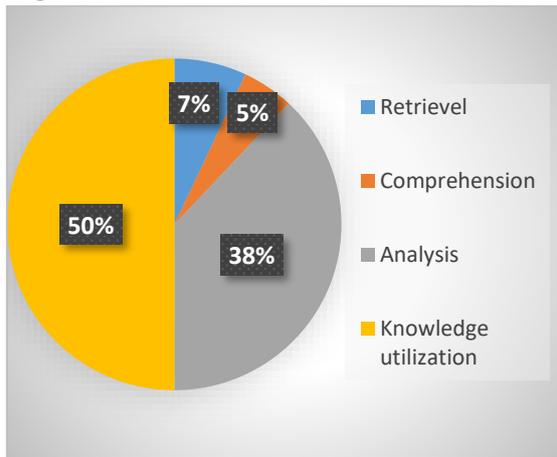


Figure 1. Percentage of UN Physics question distribution based on TIPP

Based on the results shown in Figure 1, the data analysis results show that the 40 questions of the 2019's high school national examination for physics are distributed among the four TIPP levels, with 3 (7%) questions falling under retrieval category, 2 (5%) questions under comprehension category, 15 questions (38%) under analysis category, and 20 questions (50%) under the knowledge utilization category. Based on the analysis of each sub-category, the UN questions dominantly focused on overcoming obstacles (problem solving), with as many as 14 questions falling under this category. However, there are 2 sub-categories that were not found on the UN questions, namely symbolizing and decision markers. In regards to the level of the category, knowledge utilization (level 4) has the largest portion since 20 (50%) UN questions are included in this level. It is followed by analysis category (Level 3) with 15 questions (38%). Meanwhile, questions under comprehension (level 2) and retrieval (level 1) category have the least portion, namely 2 (5%) and 3 (7%) respectively. This shows that in terms of Taxonomy of Introductory Physics Problem (TIPP), the physics questions for 2019's high school

national examination are more dominantly distributed to knowledge utilization and analysis aspects. Meanwhile, only a small number of the questions is regarding comprehension and retrieval.

Discussion

TIPP reviews cognitive systems in each knowledge domain. Cognitive systems include: 1) Retrieval, which consists of Recalling and recognizing (1a) and Executing (2a); 2) Comprehension, which consists of Integrating (2a) and Symbolizing (2b); 3) Analysis, which consists of Matching (3a), Classifying (3b), Analyzing errors (3c), Generalizing (3d), and Specifying (3e); and 4) Knowledge utilization, which consists of (4a), (4b), (4c), and (4d).

Based on the results of this study, it is discovered that in general, the 2019 UN's Physics questions are spread across all categories/indicators of TIPP, with knowledge utilization level having the highest frequency of occurring. This level, when compared to the cognitive level of Bloom's taxonomy, is equivalent to the level of reasoning, which requires higher-order thinking skills. Considering these results, it can be stated that on average, the 2019 UN's Physics questions have a high level of questions.

According to Rofiah, et.al (2013) understanding, application, and reasoning aspects of cognitive abilities as applied to TIMSS (Trends in Mathematics and Science Study) can be used to show the students' thinking ability. Understanding and application aspect are included as basic thinking skills. Meanwhile, the reasoning aspect is included as higher order thinking skills.

The information or the results of this study also show how important it is to conduct question analysis, so as to be able to

conduct cognitive evaluations effectively. This is given that the problems that often surface when conducting evaluations lie in the objectives, the approach used, the benefits, and the impact.

Kurniawan (2015) explains that question analysis is an activity that the teacher must do to improve the quality of the questions that have been composed. The purpose of question analysis is to improve the quality of test questions and discover students' diagnostic information. Quality questions are questions that can provide precise information, so that students who have mastered the material and those who have not mastered the material can be identified.

Linn and Gronlund in Kurniawan, et.al. (2017) states that the benefit of question analysis is not only limited to improving the questions, but also some other things. That is, the question analysis data is useful as a basis for: (1) efficient class discussions about test results, (2) remedial work, (3) the improvement of the learning in the classroom in general, and (3) the improvement of skills in test construction. This shows that question analysis is useful for: (1) determining questions that are defective or do not work; (2) improving the questions through three analysis components, namely difficulty level, discriminating power, and distractions, and; (3) improving learning through questions ambiguity and certain skills in which the students might struggle.

According to Nasir (2015), education must also provide benefits to students, institutions, and society. Therefore, if the evaluation of education used does not help improve the quality of education in schools and does not provide benefits, it means that the evaluation system used or implemented has not functioned as expected.

In regards to the Taxonomy of Introductory Physics Problems (TIPP): the results of this study showed that the taxonomy is able to provide an overview for the level of the questions being analyzed. This is extremely required in cognitive evaluation process of a learning process.

According to Teodorescu, et.al (2013), Taxonomy of Introductory Physics Problems (TIPP), relates physics problems to the cognitive processes needed to solve them. TIPP was created to design the objectives of education, to develop assessments that can evaluate the individual component processes of the physics problem-solving process, and to guide curriculum design for introductory physics courses, particularly in the context of the "thinking skills" curriculum. In addition, it is also possible for TIPP to be used to investigate the extent to which cognitive processes are presented.

Indahsari, et.al (2018) added that the advantages of TIPP include the placing of metacognitive processes under cognitive processes, the placing of the self system at the top of thinking process, a clear separation between affective, psychomotor and cognitive, the presence of problem solving and its arrangement from simple to complex things. This taxonomy consists of two dimensions that are contained in three systems (self-system, metacognitive system, and cognitive system) and one knowledge dimension.

The research results obtained serves as a comparison for the results of a research conducted by Sutiadi (2015) about TIPP-based analysis of the National Examination questions for Physics, which showed that only 5 types of questions are based on TIP, out of 25 types of questions found in physics textbooks.

The use of TIPP in analyzing the distribution of UN's Physics questions in

this study is in line with the results of a research by Hanakova, et.al (2016). The results of his research indicate that TIPP is suitable to be used to identify definite differences between the levels achieved in cognitive processes and knowledge domains, particularly in secondary schools.

CONCLUSION

Based on the research results obtained, it is concluded that the 2019 Physics High School National Examination questions are distributed among all aspects of TIPP, including retrieval, comprehension, analysis, and knowledge utilization with each number and percentage of each level being 3 (7%), 2 (5%), 15 (38%) and 20 (50%). In addition, the Taxonomy of Introductory Physics Problems (TIPP) is suitable to be used to analyze questions related to physics.

The researchers hope that the results of this study are able to provide an insight to teachers so that they are able to produce instruments that can accustom the students to higher-order thinking.

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