

HOTS Measured by Cognitive Learning Outcomes (CLO) Inventory Based Education for Sustainable Development as a Media for Students Skills Analysis

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Abstract

This study is a development research using the ADDIE model that aims to develop an instrument to measure higher order thinking skills in students using Education for Sustainable Development (ESD). The pilot test was conducted with fifty twelfth grade students, and the data was analyzed using the Rasch model. Validity analysis showed that nine out of ten items on the instrument were valid, based on item suitability criteria. The instrument was also found to be reliable. The results of the wright analysis on the item map showed that students' HOTS ability was still in the moderate category, with the level of difficulty of the questions ranging from -0.9 to +0.9 logits. Furthermore, the analysis of students' worksheets showed that students had difficulty in connecting their real-life experiences with real-world issues. Students' difficulties in solving ESD-based HOTS criteria questions on average are caused by students' lack of understanding of physics concepts so that students have difficulty in making physics a solution to solve global warming cases. This becomes an obstacle for students in analyzing and evaluating cases, especially for questions that demand the ability to integrate ESD dimensions in making considerations for solutions to global problems.

Keywords: HOTS; Cognitive Learning Outcomes; Sustainable Development

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INTRODUCTION

The educational landscape has changed radically given the digital and technological advancements in the 21st century. Today, we are faced with enormous and unprecedented learning challenges at every level in the education system, so education policy and practice need to play a pivotal role in how we reorient knowledge creation and education systems (Østergaard, 2021). In most societies around the world, education is considered a great asset for economic development. Education can contribute greatly to economic development when learners develop knowledge, skills and values that are necessary and appropriate for the labour market (Ozturk, 2001).

According to UNESCO (2012) pedagogy related to Education for Sustainable Development (ESD) should spur and inspire students to think critically, question and reflect. The assumption is that pedagogy moves towards student-centred participatory learning. How do we ensure that education in these extraordinary times can embody a culture of critical commitment and be engaged enough to make a real difference to socio-ecological resilience and sustainability, yet

reflexively critical enough to learn from experience and keep options open for the future (Sterling, 2016).

However, it is not easy to create a culture of critical commitment in society. Many people still do not closely connect cause and effect in problems that occur in ecological, economic and social aspects (Harangozo et al., 2018), so a paradigm shift or human perspective is needed to support sustainable development. Humans need to learn to develop knowledge, skills, values and attitudes that enable them to adapt in a changing world to support sustainability (Tarrant & Thiele, 2016). In this regard, education has an important role in accelerating progress towards a sustainable future (Findler et al., 2019; Kohl et al., 2022). UNESCO established ESD (Education for Sustainable Development) to support the UN's 2030 agenda for SDGs (Leicht et al., 2018).

Environmental problems are increasing due to increasing industrialisation and urbanisation, which deplete natural resources and generate municipal and industrial waste. Rapid economic growth is the main goal of developing countries to reduce poverty and act without considering environmental issues (Gill et al., 2018). Considering environmental issues by focussing on the ecological dimensions of complex systems is not enough to promote an understanding of sustainable development, but it is also necessary to consider the sociocultural and economic dimensions. To promote understanding of these dimensions and their interactions, systems thinking needs to be taught in schools (Riess & Mischo, 2010). This is in line with the role of ESD that rests on three pillars, namely social, environmental and economic, which are very important in changing the perceptions and attitudes of society in general (Tristananda, 2018).

HOTS have become the focus of 21st century education in the hope of fostering higher scientific thinking, critical thinking, and reasoning among humans (Made et al., 2022) where it is also considered to be a platform in creating learners who are able to support sustainable development. (Newman, 1990) defines higher order thinking skills by distinguishing between higher order thinking skills and lower order thinking skills. He notes that higher order thinking skills are those that challenge learners to "interpret, analyse and manipulate information" (p.44). In the 1950s, Bloom and his colleagues (Bloom et al., 1956) established a hierarchy of educational objectives, which has since been commonly referred to as Bloom's Taxonomy.

Higher Order Thinking Skills (HOTS) are defined as abilities that are able to provide more information, foster critical thinking, evaluate, have the ability to think metacognitively, and solve problems. Bloom's revised taxonomy with Bloom's higher order thinking assessment has three indicators, namely analysing, evaluating, and creating (Rahmi et al., 2021). (Widyaningsih et al., 2021) argue that assessment, especially in the cognitive domain, is central to the learning process and must be carried out accurately and in accordance with the subject to be assessed or measured. HOTS-oriented learning will be useless if teachers are unable to provide HOTS-based assessment. This condition will cause teachers to be unable to measure the success of the learning process (Abidinsyah et al., 2019). Various test assessment techniques and strategies can not only be used as a tool to determine students' ability profiles but can also be used as a means to train students' thinking skills (Made et al., 2022).

One of the efforts to develop higher order thinking skills is by using appropriate assessment where assessment is an integral part of learning (Rahmi & Alberida, 2017). Research on HOTS assessment in physics subjects shows that HOTS assessment instruments effectively train students' HOTS skills (Kusuma et al., 2017; Serevina et al., 2018). The development of ESD-based cognitive learning outcome instruments as a medium to measure students' HOTS is an alternative solution in achieving the goals of ESD. By measuring the level of thinking of students, teachers will easily identify the abilities of students and develop appropriate media and learning models. By adjusting learning tools according to the needs of students supported by learning content that is full of sustainable development, a sustainable generation can be created.

In order to achieve ESD goals, it is necessary to conduct learning that supports this. The most important component in measuring the achievement of learning objectives is to develop appropriate measurement tools. The development of assessment instruments in order to evaluate learning outcomes and achievement of learning objectives has been widely done. This research recommends the use of Bloom's Revised Taxonomy in setting assessment items. Achieving the 17 goals in sustainable development requires the ability to identify problems, analyse facts in the field, evaluate existing solutions, and create more efficient solution strategies based on the three pillars of sustainable development. These abilities can be measured using cognitive instruments in Bloom's revised taxonomy that are able to measure the ability of students at the high order thinking skill level, namely the C4-C6 cognitive level.

METHODS

This study focuses on developing an instrument to measure the level of critical thinking skills and knowledge of global issues related to the environment and sustainable development. The findings revealed that the current learning instruments used in schools focus on essential concepts and do not promote discourse-based learning or sustainable development. Based on the objectives of the Indonesian curriculum, the researchers developed an instrument that not only measures student learning outcomes but also helps improve students' critical thinking skills in the context of sustainable development. This instrument aims to train students in becoming active participants in building a sustainable world.

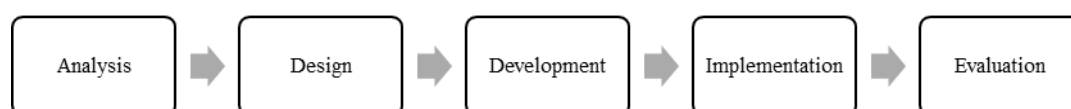


Figure 1. ADDIE Development Model

The researchers used the ADDIE development model, which involves different stages such as analysis and design. The initial analysis stage involved conducting interviews with twelfth-grade physics teachers to understand the needs of the students. The Design stage was carried out by designing learning objectives in accordance with the results of the analysis and designing the instruments to be used, at this stage the researcher decided to make an instrument in the form of essay questions. The Development stage is carried out by making instruments based on the cognitive level in Bloom's revision, namely at the C4 (Analyzing), C5 (Evaluating), and C6 (Creating) levels. Input from experts was used to ensure the

instrument was appropriate and relevant. At the Implementation stage, the instrument was tested on 50 twelfth grade students who had studied global warming material in one of the schools in Bandung city, Indonesia.

The pilot test data were analyzed using the Rasch model to determine validity and reliability. The results of this analysis show that 9 out of 10 items on the cognitive learning outcomes instrument are valid.

ITEM STATISTICS: MISFIT ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	IML MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMEASUR-CORR.	AL-EXP.	EXACT OBS%	MATCH EXP%	ITEM	
4	167	50	.48	.10	2.19	4.13	2.20	4.21	.4	.56	.48	26.0	28.5	P4
1	228	50	-.09	.09	1.75	3.06	1.75	3.02	B	.22	.54	18.0	26.0	P1
9	221	50	-.04	.09	1.18	.53	1.05	.32	C	.62	.53	26.0	26.4	P9
3	243	50	-.21	.09	.92	-.32	.87	-.62	D	.36	.55	48.0	25.2	P3
10	204	50	.11	.09	.87	-.57	.85	-.67	E	.51	.52	24.0	26.6	P10
7	221	50	-.04	.09	.83	-.02	.82	-.05	e	.69	.53	18.0	26.4	P7
2	216	50	.01	.09	.77	-1.15	.76	-1.18	d	.52	.53	32.0	26.2	P2
6	236	50	-.16	.09	.70	-1.50	.74	-1.30	c	.72	.55	24.0	25.3	P6
8	191	50	.23	.10	.70	-1.50	.73	-1.29	b	.51	.50	34.0	27.2	P8
5	253	50	-.29	.09	.70	-1.67	.66	-1.90	a	.57	.56	32.0	24.2	P5
MEAN	218.0	50.0	.00	.09	1.05	.01	1.04	-.02				27.4	26.2	
P.SD	24.1	.0	.21	.01	.48	1.92	.49	1.92				6.7	1.1	

Figure 2. Output Item Fit Order

The results of the limited trial which were analysed using the Rasch model showed that item number 1 was the only item that did not meet 1 of the following 3 item suitability order criteria, namely $0.50 < MNSQ < 1.5$; $-2.0 < ZSTD < +0.2$ and $0.4 < Pt Mean < 0.85$.

PERSON	50 INPUT	50 MEASURED	INFIT	OUTFIT				
	TOTAL	COUNT	MEASURE	REALSE	IMNSQ	ZSTD	OMNSQ	ZSTD
MEAN	43.6	10.0	-.04	.23	1.01	.0	1.04	.0
P.SD	9.7	.0	.39	.04	.58	1.2	.60	1.2
REAL RMSE	.23	TRUE SD	.31	SEPARATION	1.33	PERSON RELIABILITY	.64	

ITEM	10 INPUT	10 MEASURED	INFIT	OUTFIT				
	TOTAL	COUNT	MEASURE	REALSE	IMNSQ	ZSTD	OMNSQ	ZSTD
MEAN	218.0	50.0	.00	.10	1.05	.0	1.04	.0
P.SD	24.1	.0	.21	.02	.48	1.9	.49	1.9
REAL RMSE	.10	TRUE SD	.19	SEPARATION	1.84	ITEM RELIABILITY	.77	

Figure 3. Output Tabel Item Summary Statistics

Finally, at the Evaluation stage, validity and reliability analyses were conducted to assess how well the instrument measured the learning objectives and determined students' cognitive abilities. The question instrument is a description question with a minimum score range of 0 to 10 for each question so that the maximum score that can be obtained is 100. The scoring criteria on the question instrument are as follows:

Table 1. Question Assessment Criteria

Score	Criteria
0	Did not give an answer.
1-3	Attempts to give an answer but it is wrong.
4-6	Answered incorrectly but provided information appropriate to the case, showing correct elements related to the theory or concept related to the case discussed in the question.
7-9	Answered correctly but incomplete
10	Answered correctly, provided in-depth analysis, appropriate solution

with correct reasoning and showed understanding of the concept and was able to explain the cause and effect relationship according to the case discussed in the question.

Data analysis is carried out to process data that has been obtained from the results of implementation in the form of student worksheets. Data processing is carried out in accordance with the data that has been obtained, the data analysis is described as trails (Sugiyono,2017):

$$\% \text{ Student Learning Outcomes} = \frac{\text{Sum of total scores}}{\text{Sum of Ideal Scores}} \times 100\%$$

this quantitative descriptive analysis by calculating the percentage of student learning outcomes on each item number.

RESULTS AND DISCUSSION

The level of critical thinking skills of students measured using ESD-based cognitive learning outcomes instrument mapping can be seen in Figure 4. The results of the analysis shown by the person map item show that, question number four is the most difficult question for students to answer, where question number 4 is at the level of analyzing, meaning that only 14% of the total number of students are able to investigate the social and economic impacts of the impacts caused by global warming and solutions in dealing with these impacts so that when viewed from the dimensions of sustainable development, students are still lacking in the social and environmental dimensions. But on the other hand, students E, F, T, AS, H have a higher ability compared to the difficulty level on the most difficult question to answer with a logit value > +0.6, this indicates that 10% of the sample has the ability to provide logical and creative answers.

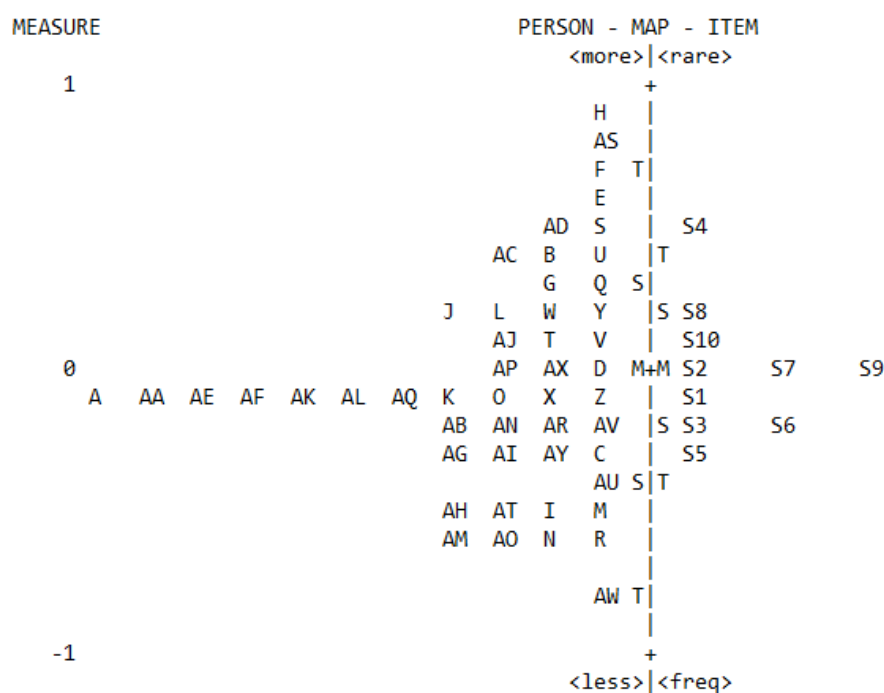


Figure 4. Person Map Item

Furthermore, based on the wright map in Figure 4, the average level of students' HOTS thinking skills is in the medium category. Learners AU, S, AH, AT, I, M, AM, AO, N, R, AW, and T have a logit value > -0.3 where they have abilities below the difficulty level of the question. This indicates that these learners still have low-level thinking skills for sustainable development-based questions because they have difficulty in analyzing cases that require the ability to analyze, evaluate, and create real solutions related to environmental problems

At cognitive level C4 (Analyzing), there are still about 30% of the total number of students who are still unable to analyze problems related to the phenomenon of climate change and fossil fuel energy consumption with logit values in the range -0.3 to -0.9 . C5 cognitive level (Evaluate), about 22% of students have the ability below the difficulty level of the question, this illustrates that about 78% of students who were sampled in this study have the ability to evaluate the case of waste as a cause of CO₂ emissions and extreme weather phenomena due to global warming, but the results of the LKPD analysis show the weakness of students in evaluating cases because although students have been able to provide evaluations based on the knowledge they have, the reinforcing facts provided by students to support their statements are still less reflective and creative.

C6 cognitive level, at this level it can be seen that from the total number of samples, only 38% of students were able to reach this level. This picture shows the weakness of students who have logit values in the range -0.1 to -0.9 in creative thinking to create real solutions based on cases related to the use of electrical equipment and CO₂ gas emissions that have a global impact. In this case, students are still weak in making critical considerations of the problems that occur, they are still not capable enough to make alternative solutions in dealing with climate change that has social and environmental impacts on society.

Table 2. analysis of students' cognition level based on students' answer representation

Students Answers	Student Answers Analysis
<p>Indicator: Analyse the effect of global warming on sea levels (C4)</p> <p><i>Berdasarkan gambar 1, luasan warna putih pada gambar merupakan luasan es yang mengalami penysutan. Pada tahun 2022, luas es laut Antartika tahunan mencapai rekor terendah yaitu 4,09 juta mil persegi. Menurut analisis Pusat Data Salju dan Es Nasional (NSIDC) berdasarkan data dari NOAA dan NASA. Luas es laut Antartika mencapai 3,36 juta mil persegi atau sekitar 660.000 mil persegi di bawah rata-rata dari tahun 1991 hingga 2020. Ini merupakan luasan terendah kedua dalam catatan satelit selama 44 tahun, setelah tahun 2016.</i></p> <p><i>Jika pemanasan global berlanjut sampai 100 tahun berikutnya, Jelaskan pengaruhnya terhadap permukaan air laut di seluruh dunia?</i></p> <p><i>Permukaan air laut akan naik sehingga dapat mengakibatkan daratan yang ada di bumi tenggelam. Sehingga populasi makhluk hidup di bumi akan punah.</i></p> <p>Student answer: The sea level will rise, which will cause the land on earth to sink and the population of living things on earth will become extinct</p>	<p>In this question, the answers are quite correct, but the drawback is that students have not provided in-depth analysis related to the answers given and how the physics concept explains this. So that the answer above can be categorised into understanding level.</p>
<p>Indicator: Analyse the relationship between dependence on fossil fuels and global warming mitigation (C4)</p>	<p>The answer given by this student is not wrong but it seems that students are not sufficiently able to analyse the relationship based on the questions and discourse given</p>

Berdasarkan data Kementerian ESDM RI, konsumsi energi Indonesia yang cukup tinggi hampir 95% dari bahan bakar fosil. Dari total tersebut, hampir 50% nya merupakan Bahan Bakar Minyak (BBM). Jika pemanfaatan energi menjadi salah satu faktor besar dalam menyumbang gas rumah kaca maka bagaimana hubungan antara penanggulangan pemanasan global terhadap cara mengurangi kebergantungan pada bahan bakar fosil?

Mengurangi kebergantungan pada bahan bakar fosil dan menggantinya dengan sumber energi lain yang lebih ramah lingkungan adalah salah satu tindakan penanggulangan pemanasan global.

Student answer: Reducing dependence on fossil fuels and replacing them with other energy sources that are more environmentally friendly is one of the actions to combat global warming

Indicator: Analyse the effect of global warming on extreme weather due to climate change (C4)

Berdasarkan jawaban anda pada poin (a) dan (b), korelasikan pengaruh pemanasan global terhadap cuaca ekstrem akibat perubahan iklim!

Pengaruh terjadinya pemanasan global maka suhu di udara menjadi tak menentu. Bisa tiba-tiba panas, bisa dingin. Dengan cuaca ekstrem, tubuh menjadi lemah sehingga mudah sakit.

Student answer: With the occurrence of global warming, the air temperature becomes erratic, it can be suddenly hot, suddenly cold with extreme weather, the body becomes weak so that he is susceptible to disease

Indicator: Investigate the social and environmental impacts of climate change as a result of global warming and solutions to deal with it (C4)

Fakta di atas menunjukkan bahwa pemanasan global telah menyebabkan perubahan iklim cukup ekstrem. Jelaskan dampak sosial dan lingkungan dari cuaca ekstrem yang disebabkan oleh perubahan iklim, serta tindakan yang dapat diambil oleh masyarakat global untuk menghadapinya!

Dampak sosial dan lingkungan yang akan kita alami. Salah satunya timbulnya penyakit karena perubahan yang cukup ekstrem. Solusinya kita harus bersiap diri untuk menghadapi cuaca yang ekstrem seperti selalu berolahraga, minum vitamin yang cukup dan banyak istirahat.

Student answer: One of the social and environmental impacts that we will experience is the emergence of diseases due to extreme changes. The solution is to prepare ourselves for extreme weather such as always exercising, taking enough vitamins and getting plenty of rest.

Indicator: Examine alternative energy source solutions related to electrical energy consumption in Indonesia (C5)

so it appears that the ability of students based on the answers above is still at the understanding level (C2).

The answers given by students are still at the describing the impact of global warming, this is not in accordance with the indicators to be achieved where students have not been able to link the conceptual knowledge they have with the facts presented in the problem.

Student is able to explain the social impact of extreme weather but unfortunately they has not provided enough in-depth analysis related to the problems arising from global warming and how to overcome them using procedural and conceptual knowledge appropriate to the case

The answers given by students were not in accordance with the questions given, students did not answer questions related to alternative solutions by the government, besides that the opinions presented by students did

Menurut anda, Apakah alternatif solusi yang ditawarkan pemerintah dengan menggunakan bahan bakar fosil dalam memenuhi kebutuhan energi di Indonesia sudah tepat?. Jika tidak berikan alternatif sumber energi yang dapat digunakan untuk memenuhi kebutuhan energi di Indonesia? Jelaskan pendapat anda dengan menyertakan bukti yang relevan!

Alternatif sumber energi yang dapat digunakan dalam memenuhi kebutuhan energi di Indonesia adalah energi listrik. Jelaskan sudah banyak transportasi yang menggunakan energi listrik. Bagi bahan bakar fosil akan habis. Meskipun banyak kurang lebihnya dampak positifnya mungkin akan lebih terasa.

Student answer: An alternative energy source that can be used to fulfil energy needs in Indonesia is electrical energy. Now there are many transportations that use electrical energy so that fossil fuels do not run out, although there are many disadvantages, the positive impact may be felt.

Indicator: Assess the Government's attempt to tackle the problem of waste as a cause of global warming (C5)

Menurut anda, apakah upaya yang dilakukan pemerintah telah menjadi solusi yang tepat dalam menanggulangi masalah sampah?. Jelaskan bagaimana sampah berkontribusi terhadap pemanasan global, termasuk proses-proses yang terlibat dalam pembusukan sampah dan emisi gas rumah kaca yang dihasilkan!

Mungkin tepat, karena dengan adanya TPS belum tentu pemerintah dapat mengolah sampahnya dengan baik. Sampah jika diolah dapat membuat polusi udara yang parah. Gas yang dihasilkan dari pembusukan sampah juga dapat mengakibatkan gas rumah kaca.

Student answer: Not right, because the existence of TPS does not mean that the government can process the waste properly. Waste when burned can create severe air pollution, the gas produced from decomposing waste can also cause greenhouse gase

Indicator: Evaluate the influence of human lifestyle on climate change (C5)

Evaluasi peran dari gaya hidup manusia dalam menghasilkan emisi gas rumah kaca dan merusak lingkungan serta jelaskan bagaimana perilaku manusia, termasuk konsumsi energi, pola makan, mobilitas, dan pemborosan, dapat mempengaruhi perubahan iklim!

Semua perilaku manusia dapat sangat berpengaruh terhadap perubahan iklim. Contohnya sering membeli makanan sendiri dan tidak membeli makanan dari luar itu bisa mengurangi jumlah sampah rumah yang dihasilkan.

Student answer: All human behaviour can greatly affect climate change. For example, often making our own food and not buying food from outside can reduce plastic waste.

Indicator: Design ideas to solve the problem of global warming symptoms and its impact on life and the environment (C6)

Buatlah daftar rencana yang akan anda lakukan untuk mengurangi dampak pemanasan global!

- mengurangi rumah kaca karena efek rumah kaca sangat berpengaruh kepada pemanasan global

- Melakukan peboisasi setelah penebangan

- Menghancurkan sisa makanan dari TPS

Student answer: Reducing greenhouses because the greenhouse effect greatly affects

not show a deep connection with the energy consumption data in the question

Here students have been able to determine opinions related to waste management by the government and their reasons but have not really fulfilled the demands of the question by providing an in-depth study related to the contribution of waste so it appears that students only use their factual knowledge and little of their conceptual knowledge

The answers given by students are not wrong, but here students only give a general opinion and then give an example without linking it to the concepts they have learned while the questions in the questions are specific enough to be evaluated. So that students only understand one of the causes of global warming

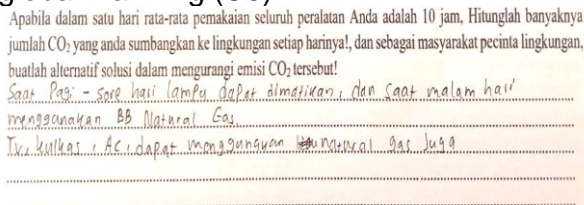
In this question, it is actually expected that students can use their procedural and metacognitive knowledge to make plans, but students' answers only show the statements they get from the textbook. Whereas students can make a list of concrete plans based on the habits they do, which in this case is improving daily habits by students can be a

global warming, reforestation after logging, eliminating food waste from landfills.

solution in reducing the impact of global warming itself.

Indicator: Create alternative solutions related to electricity consumption that causes CO₂ emissions as a concrete action to tackle global warming (C6)

The answer given by the students is not wrong because they have been able to determine that LNG provides less emissions compared to coal but in this case the participants are only at the conceptual knowledge level when they should be able to use procedural knowledge to produce the right answer by providing a more in-depth analysis by connecting human lifestyles with the causes of global warming.



Student answer: Switch off the lights in the morning and use natural gas at night, and use natural gas for TV, refrigerator, and air conditioner.

The results of the analysis in Table 2. show that students on average only provide answers based on the material they understand and remember from the results of the learning process they follow, the shortcomings are that they have not been able to provide their own meaning from the case given, they are still lacking in providing strong analysis, appropriate and real solutions by them and showing a deep understanding of concepts related to causal relationships that are in accordance with the case or discourse given in the problem.

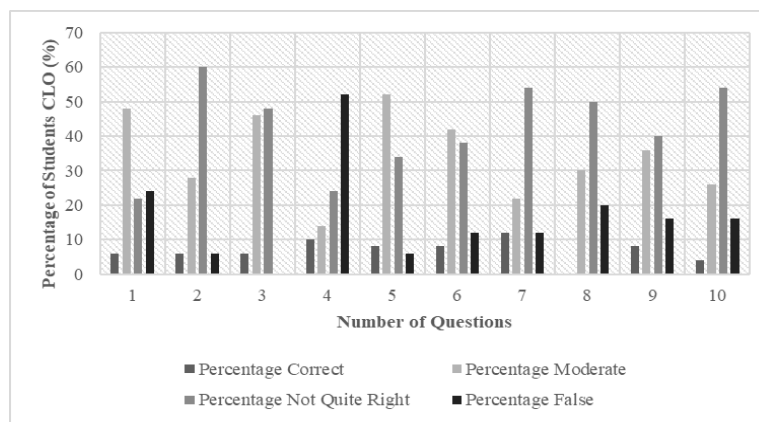


Figure 5. Percentage of Students Cognitif Learning Outcomes

According to the statistics in Figure 5, questions number 3 and 5 have the highest percentage of correct student answers. In question number 3, all students answered correctly, but the distribution of partially correct and less correct answers is almost the same, indicating a cognitive level of C6. Question number 5 had a higher percentage of correct answers compared to incorrect answers, despite being at a cognitive level of C5. On the other hand, field data revealed that questions number 2, 7, 8, and 10 had more incorrect answers than correct ones. These questions, which fall within the cognitive levels of C4-C6 as seen in Table 3, showed that students tend to give less precise answers.

Based on the data analysis, it is found that question number 1, which requires a cognitive level of C4, has the highest number of correct answers from

students. On the other hand, question number 4, which also requires a cognitive level of C4, has the highest number of wrong answers, exceeding 50%. This indicates that most students struggle with analyzing complex questions that require a detailed understanding of the government's efforts in addressing waste-related issues and its contribution to global warming. The questions included in the Cognitive Learning Outcomes (CLO) Inventory Based Education For Sustainable Development consist of global and national cases related to responsible production and consumption. These questions are designed to assess students' ability to analyze, evaluate, and create, and are in the form of essay questions that require good writing and communication skills to provide suitable answers based on the given issues or cases. The instrument in this study was deliberately made so as to be able to measure students' critical thinking skills in answering complex questions and requiring a high level of analytical ability.

There are two types of HOTS skills: analytical and creative thinking skills. Analytical or logical thinking skills enable critical thinking and help choose the best alternative (Bednarz, 2011; Cottrell, 2011, 2013). Previous research reported that most teachers found it difficult to formulate learning outcome assessment instruments, especially HOTS questions (Istiyono, 2018) assessment itself is an activity of collecting and processing information to measure the achievement of student learning outcomes and aims to monitor and evaluate the process, learning progress, and continuous improvement of student learning outcomes (Hairun, 2020; Permana et al., 2021).

The results of a limited trial show that, on average, more than 45% of learners gave incorrect answers to a set of ten questions. The number of learners who answered correctly was significantly lower than those who answered incorrectly, even though there were a few questions where a significant number of learners provided answers that were close to the expected answers. This indicates that learners have not yet developed higher order thinking skills, and are unable to relate their real-life experiences to problems in the real world. The high number of wrong answers to questions with cognitive levels C4 and C5, particularly questions 2, 7, and 10, suggests that most students are unable to evaluate their own habits and lifestyles based on the issues presented. This also indicates that students have a lifestyle that is not oriented towards sustainable development. Furthermore, most students have not reached the C6 cognitive level, as evidenced by the incorrect answers to questions 3, 8, and 9.

Problems with ESD-based HOTS criteria are solved by students by understanding the environmental cases contained in the problem. They are asked to use their metacognitive knowledge to be able to understand cases related to climate change and the impacts caused by global warming, then linked to the real experiences of students to facilitate students in evaluating lifestyles that cause global warming and facilitate students in making real solutions that are logical, reflective, and creative. The difficulty of students solving HOTS criteria questions is on average due to the lack of understanding of the physics concept of students so that they have difficulty in making physics a solution to solve global warming cases. They have not been able to use the concepts of effort and energy to calculate the amount of CO² gas emissions caused by household electrical appliances. This is an obstacle for students in analyzing and evaluating cases, especially for questions that require the ability to integrate ESD dimensions (social, economic,

environmental, and cultural) in making considerations for solutions to global problems.

The results of the analysis showed that although some students were able to provide answers to the questions given, the HOTS abilities of the students were still in the medium category. Achieving high-level thinking skills for students certainly requires learning that involves students to be active in analyzing, evaluating, and creating activities. A learning process that is able to help learners build their knowledge and be literate in global cases so as to create sustainable learners. Some learning models that can help in improving students' thinking skills include problem-based learning, inquiry learning, and discovery learning that can help students in constructing their physical knowledge.

CONCLUSION

Validity analysis using the Rasch Model showed that nine out of ten items on the instrument were valid, based on the item suitability criteria. The instrument also proved to be reliable. The results of the item map analysis showed that students' HOTS ability was still in the moderate category, with the difficulty level of the questions ranging from -0.9 to +0.9 logits. Furthermore, the analysis of students' worksheets showed that students had difficulty in connecting their real-life experiences with real-world issues. The students' difficulties in solving the ESD-based HOTS criteria questions on average are caused by the students' lack of understanding of physics concepts so that students have difficulty in making physics a solution to solve global warming cases. This is an obstacle for students in analyzing and evaluating cases, especially for questions that demand the ability to integrate ESD dimensions in making considerations of solutions to global problems. In the future, to assist students in achieving high-level thinking skills that are able to reach all cognitive levels well, it is necessary to apply learning models that help students in constructing their knowledge so as to produce sustainable students.

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