Science and environment for education: Measuring HOTSEP of electricity energy topic using Ichsan and Rahmayanti taxonomy

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Abstract. Learning science in the 21st century focuses a lot on caring for the environment. This study aimed to measure students’ HOTSEP (Higher Order Thinking Skills of Environmental Problem) in the context of environmental problems related to electricity. The descriptive method was used with a sample size of 50 students from several cities in Indonesia. The HOTSEP instrument consists of 3 categories of thinking levels ranging from criticizing environmental problems (C4), solving environmental problems (C5), and developing innovations about the environment (C6). The results showed that the HOTSEP of students was included in the "medium" category (50.41). These results indicate that the level of understanding of electrical concepts and their implementation at the student level in general still needs to be improved. Suggestions for further research, understanding environmental concepts of electricity needs to be introduced to students in general so that they can apply it in their daily lives for the better.

Keywords: HOTSEP, electricity, environmental learning.

1. Introduction
Environmental education has long been recognized and used as a goal to improve good relations between humans and their environment[1]. Education has a major role in creating awareness and understanding of environmental problems. Through education, humans can create and utilize science and technology that is useful in learning. Environmental education encompasses approaches, tools, and programs that increase and maintain environmentally-related attitudes, values, awareness, knowledge, and skills that train people to take learned action on behalf of the environment [2]. Environmental awareness is not entirely a talent or instinct for failure, but is a result of the general education process [3]. Environmental awareness is needed to create a positive impact on the behavior of human interactions with the surrounding environment. Although Environmental education addresses wicked problems such as climate change or biodiversity loss [4], environmental problems around us are often ignored and not discussed in environmental learning at the tertiary level of education [5]. Students have a very important role to contribute to the environment by having the ability to think at a high level so that they can analyze well, provide creative ideas and make an innovation to minimize environmental problems [6].
Students need to be instilled in having a caring attitude towards the environment by paying attention to the latest environmental conditions and providing knowledge to protect the environment. Environmental education leads not only to conservation actions and behaviors but also to real environmental improvements [7]. Environmental learning has an important role in providing various knowledge to students related to electricity. The knowledge provided is in the form of Higher Order Thinking Skills (HOTS), where these skills must include sub-skills such as analysis, synthesis, evaluation, and making problem solutions [8]. Higher Order Thinking Skills (HOTS) is an important aspect of solving environmental problems, in this case, it is related to 21st century learning [9].

Recent research trends indicate that in science education focus on higher order thinking skills (HOTS). Previous research also explored that it is very important to assess students higher order thinking skills in science using different assessment techniques in the classroom [10]. Assessment of higher order thinking skills based on environmental problems is called Higher Order Thinking Skills Assessment Based on Environmental Problems (HOTS-AEP) [11]. HOTS-AEP is an assessment of environmental based on contextual aspect. This learning was important to improve 21st century learning [12]. This instrument focuses on environmental pollution problems. The difference between HOTS (previous version of taxonomy by Anderson et al, 2001) and HOTSEP (Higher Order Thinking Skills of Environmental Problem) new taxonomy in the analysis position (C4) is raised to solve environmental problems (C5), evaluating (C5) is lowered to criticize the problem environment (C4), creating (C6) is at the highest level but transformed to develop environmental innovation (C6). Previous research has created a new dimension of HOTS called HOTSEP and revised Anderson taxonomy, but the context for problem solving is in the very low category. This shows that they do not fully understand the various thinking skills for environmental learning [13]. Based on this description, HOTSEP measurement research needs to be developed in the learning environment at universities. HOTSEP student research to find out the problem of the learning environment in the electrical context.

2. Methods

2.1 Samples and Data Collection
This study was conducted in September 2020. The research sample was 50 students from several cities in Indonesia who were randomly selected by simple random sampling. The sample was divided into 20 males and 30 females at the university level. Data collection is done online via Google form.

2.2 Analyzing Data
This study conducted a HOTSEP descriptive analysis to measure student knowledge in the context of an electrical learning environment. Data analysis using HOTSEP category. These results will be categorized in the HOTSEP category according to Ichsan & Rahmayanti [13]. These categories are very high, high, medium, low, and very low which can be seen in Table.

| Category   | Interval Score |
|------------|----------------|
| Very high  | X > 81.28      |
| High       | 70.64 < X ≤ 81.28 |
| Moderate   | 49.36 < X ≤ 70.64 |
| Low        | 38.72 < X ≤ 49.36 |
| Very low   | 38.72          |

*Source. The category and interval scores were adapted from Ichsan et al. (2019)*

Data were analyzed using Microsoft Excel. The technique used is to make an average for each item and also for each indicator. Analyzing the data in this way makes it easy to measure the HOTSEP amount for each indicator.
2.3 Instruments
The instrument used in this study was HOTSEP with 3 levels/aspects of thinking (The level of thinking in Ichsan and Rahmayanti Taxonomy is called cognitive processes), namely criticizing environmental problems (C4), solving environmental problems (C5), developing environmental innovations (C6).

HOTSEP descriptive analysis was conducted to measure students' knowledge in the context of electricity in the learning environment. In this research, 12 instrument items and 6 indicators were developed based on HOTSEP thinking level. The instrument used is an interval score from 0 to 10 for each measured item, more details can be seen in Table 2.

| No  | Aspect (Level of Thinking)                                | Indicator                                                                 | Item |
|-----|-----------------------------------------------------------|---------------------------------------------------------------------------|------|
| 1   | Criticizing environmental problems (C4)                   | Criticizing community behavior that is still frequent wasteful of electricity usage | 1,2  |
| 2   | Criticizing environmental problems (C4)                   | Criticizing the role of society in saving electricity usage                | 3,4  |
| 3   | Solving environmental problems (C5)                       | Solving the problem of very wasteful electricity usage                     | 5,6  |
| 4   | Solving environmental problems (C5)                       | Providing solutions to the problem of wasteful use of electricity          | 7,8  |
| 5   | Developing innovation about environment (C6)              | Developing innovative projects to solve the problem of electricity waste   | 8,10 |
| 6   | Developing innovation about environment (C6)              | Developing simple program innovations with an online system to encourage people to maintain electricity savings | 11, 12 |

3. Results and Discussion
Showed that the HOTSEP category of students was still in the moderate category in the learning environment related to electricity that needed to be improved. The items with the lowest score in items 11 and 12 are related to the development of innovative programs related to electricity, which can be seen more clearly in Table 3.

| No  | Item                                      | All (n = 50) | Male (n = 20) | Female (n = 30) |
|-----|-------------------------------------------|--------------|---------------|-----------------|
| 1   | Criticizing people who are often wasteful of electricity use | 0.64         | 0.64          | 0.63            |
| 2   | Criticizing and advising on people's behavior in saving electricity | 0.62         | 0.66          | 0.59            |
| No | Item                                                                 | All (n = 50) | Male (n = 20) | Female (n = 30) |
|----|---------------------------------------------------------------------|--------------|---------------|----------------|
| 3  | Criticizing people's behavior in protecting the environment to save electricity usage | 0.52         | 0.57          | 0.49           |
| 4  | Criticizing people's behavior that is still wasteful in using electricity | 0.53         | 0.54          | 0.53           |
| 5  | Giving a problem solution of using electricity                       | 0.55         | 0.51          | 0.58           |
| 6  | Providing ideas to solve the problem of electricity waste           | 0.58         | 0.52          | 0.62           |
| 7  | Solving the problem of electricity waste                            | 0.52         | 0.49          | 0.54           |
| 8  | Solving the problem solutions to address of electricity saving      | 0.47         | 0.4           | 0.52           |
| 9  | Solving the problem electrical waste                                | 0.49         | 0.48          | 0.50           |
| 10 | Developing an innovation electrical waste                           | 0.39         | 0.43          | 0.37           |
| 11 | Developing an innovative ideas program conducted in social media so that the public can save electricity | 0.37         | 0.31          | 0.40           |
| 12 | Developing an environment based innovative to overcome the problem of electricity savings | 0.37         | 0.32          | 0.40           |

**Raw Score**

|                      | All (n = 50) | Male (n = 20) | Female (n = 30) |
|----------------------|--------------|---------------|----------------|
| Total Score (Interval 0-100) | 60.05        | 59.0          | 62.1           |
| Category             | Moderate     | Low           | Moderate       |

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Table 4. Average HOTSEP score for each indicator

Based on the results of the analysis for each aspect/level of thinking, it shows that students are good enough at the level of environmental innovation development (C6) for all students. This is because at the innovation development stage there are still many students who have not been able to develop their original ideas, still with conventional and non-innovative ideas, even though some have been able to develop their innovative ideas but have not been able to apply and publish the environment.
Table 5. Average HOTSEP scores for aspects / level of thinking

| No | Aspect (Thinking Level) | All (n = 50) | Male (n = 20) | Female (n = 30) |
|----|-------------------------|-------------|--------------|----------------|
| 1  | Criticize environmental problem (C4) | 0.58 | 0.6 | 0.56 |
| 2  | Solve environmental problem (C5) | 0.53 | 0.47 | 0.48 |
| 3  | Develop innovation about environment (C6) | 0.40 | 0.38 | 0.41 |

The results of the research were generally quite good at developing innovation. This is because the ability to use existing tools and materials as well as increasingly complex sources of information and knowledge for innovation development will be easier to make and apply. Therefore, in 21st century learning, students' creativity and innovative ideas are highly valued.

HOTS measurement research uses a new level of thinking called HOTSEP which is more relevant in current issues related to environmental learning. Based on the HOTSEP table results obtained 49.16 for men in the low category and 51.75 for women in the moderate category. Thus, the average is classified as moderate, with a score of 50.41. This is because women's high-order thinking skills are still better than men in criticizing problems (C4), providing problem solving (C5), and developing innovations about the environment (C6) This instrument is used to evaluate student knowledge based on various environmental problems. Environmental learning was important to be improve according to contextual situation [14-15].

Environmental problems related to electricity are very important, need to be discussed, and will affect students' higher order thinking skills. Environmental learning about energy system regulation including electrical materials[16]. The short-term and long-term energy savings will have a positive impact and be more beneficial for future life [17]. At present, if the environmental problem of using electricity exceeds the limit of its use, it will have a very large impact and lead to electricity waste. Therefore, innovations were made in protecting the environment to save electricity. These innovations can be in the form of innovative programs created by students. New ideas that are unique and implemented are called innovation. Students are not only asked to be critical and solve environmental problems but also asked to have innovative programs to solve various problems, in this case, electricity problems. Environmental problems may let students use innovative ideas to improve direct environmental quality [18]. Environmental innovation as an effective way to solve environmental problems that are difficult to solve so that it can improve the quality of life[19].

Students who have high HOTSEP scores can solve the problem of electricity waste by replacing other alternative energy which is environmentally friendly, good HOTSEP scores can solve the problem of electricity waste, low HOTSEP scores are not able to solve environmental problems. Students' problem-solving skills will be enhanced when they would able to solve environmental problem, and this skill is one of the vital skills of 21st century education [20]. Therefore, students are expected to be able to innovate so that people want to save on electricity usage. Innovative students will be able to think about creating programs that can invite people to work together in protecting the environment and conserving electricity. In general, at universities, innovative students develop scientific work by combining modern technology [21]. In general, the HOTSEP instrument is very suitable for measuring students' thinking skills related to environmental problems, because the HOTSEP instrument prioritizes problems that focus on environmental problems. The HOTSEP results show that the level of understanding of electrical concepts and their implementation at the student level is in the medium category so it still needs to be improved. This environmental learning must be improved because there were many environmental problems need to be solved [22-26].

4. Conclusion
Based on the HOTSEP results of students in the context of solving problems related to electricity, the category is quite good. This shows that students already understand various thinking skills related to electricity but still need to be improved in their implementation. The lowest HOTSEP score is related to
the development of environmental innovations (C6). Thus, innovative learning is directed at designing learning that can facilitate students to acquire knowledge. Suggestions for further research are that an understanding of environmental concepts of electricity needs to be introduced to students and the general public so that HOTSEP can be better.

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