Climate Change HOTS for Designing Smart Trash in Elementary Schools

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Abstract. Environmental degradation triggers the numerous impacts of climate change. This research describes the Higher-Order Thinking Skills (HOTS) of vocational high school students and university students regarding climate change to develop a Smart Trash. The research method used is descriptive method with survey technique. Essay tests are used as the research instrument. The essay questions are comprised of 12 items with 6 indicators. The research finds that the HOTS scores of both vocational and university students are in the very low category, especially in the creative-thinking aspect. The average scores of climate change HOTS for vocational and university students are 25.60 and 30.23, respectively. The research result indicates that Smart Trash as a learning medium should be introduced in the form of project assignments for both vocational and university students. This research concludes that the HOTS score is low and needs an improvement to create a Smart Trash. The suggestion for further research is to improve students’ HOTS in vocational education and universities by developing HOTS learning.

1. Introduction

Environmental problems in the 21st century is widely discussed and becomes an interest due to their occurrence in our surroundings, such as global warming. The global warming effect would increase the intensity of extreme climatic event that would consequently drive extreme climate change on earth [1][2]. Global warming undeniable since various climate change-related cases have occurred; therefore, global warming prevention requires human beings with responsibilities and collective needs for the environment who can well manage the environment [3][4][5].

Environment wellness requires human beings with sufficient competence and mastery of the environmental knowledge so that, they may make wise decisions when faced with environmental
problems by considering the environmental conditions. The ability in making decisions and solving environmental problems wisely can be honed from high school to university through Higher Order Thinking Skills (HOTS)-based learning. The HOTS-based learning would familiarize students to think on higher cognitive levels outside of the various measures to environmental problems that are commonly taken [6][7][8].

Students with frequent exposure to HOTS-based environmental learning would have an easier time in making decisions to complex environmental problems [8]. They could create renewable innovations to solve the problems. As such, it is necessary to allow students with proven understanding and mastery of skills or competencies to innovate and understand environmental problems. It is assumed that vocational high school students and engineering students can play this role, as they are deemed capable of creating renewable and environmentally friendly innovations.

Renewable and environmentally-friendly innovation is a requirement for a product to be accepted by the community. The product resulted from innovation can simplify human tasks and help solve environmental problems. Smart Trash can be used as an example of the result of a renewable and environmentally-friendly innovation [9]. Smart trash sorts dry and wet waste, organic and inorganic waste so that it will simplify waste-processing. Moreover, it can be used as a learning medium for vocational students and engineering students to innovate and help solve environmental problems, climate change in particular. It can also be used in environmental education at elementary school level since students at this level need more environmental learning.

There are several environmental problems other than climate change. Therefore, the opportunities are wide open for vocational and engineering students to create renewable and environmentally friendly innovations to contribute to solving environmental problems. This contribution could start with an understanding of environmental problems through HOTS-based learning. This research aims to describe the HOTS of vocational and students with the goal of developing Smart Trash as a 21st century learning innovation in elementary schools.

2. Method
This research employs the descriptive method with a survey as a data collection technique. The research sample included vocational and university students selected using a simple random sampling. Total samples used in this research were 216 vocational students and 48 college students. The instrument used in the research was essay tests with HOTS level categories related to climate change. The HOTS questions prepared were 12 items that consisted of 6 indicators and 3 aspects according to Anderson et al. [10]. Results of data analysis were interpreted using HOTS categories by referring to Ichsan et al. [11] as presented in Table 1.

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

The HOTS analysis results will be a basis to develop a learning medium of Smart Trash that can be used as an education tool for students. Smart Trash development is based on the latest technology and is easy to use at any place. During the Covid-19 pandemic, the use of Smart Trash becomes a solution since it works automatically, thus reducing contact between human and the trash bin to prevent infection.

3. Results and discussion
The research results indicate that the HOTS score of vocational and university students are in the low category. The low category was related to the low implementation of HOTS-based environmental learning.
learning in class during learning activities. The research results also suggest that the lowest score is in item number 12 (see Table 2) indicating that both vocational and university students still lack creativity in solving problems.

Table 2. Results of students’ HOTS measurement for each item

| No | Item                                                                 | Vocational students (n=216) | University students (n=48) |
|----|----------------------------------------------------------------------|-----------------------------|---------------------------|
| 1  | Provide an analysis of climate change phenomenon occurred            | 3.20                        | 3.17                      |
| 2  | Create an analysis of community participation to decrease the global warming effect | 2.48                        | 2.90                      |
| 3  | Provide an analysis of why climate change becomes an issue that needs to be solved together? | 2.51                        | 3.13                      |
| 4  | What are the impacts of climate change on flora and fauna?           | 2.63                        | 3.29                      |
| 5  | Provide a critique on the use of excess carbon gas emission-containing vehicles | 2.54                        | 2.83                      |
| 6  | Can excess carbon gas have an impact on climate change? Describe your opinion. | 2.45                        | 3.15                      |
| 7  | What is your opinion on the use of Chlorofluorocarbon (CFC)         | 2.56                        | 3.40                      |
| 8  | Why do you think there are not many climate change campaigns in the country? Please explain | 2.47                        | 3.04                      |
| 9  | Create an innovative idea on the use of Chlorofluorocarbon (CFC)    | 2.68                        | 2.98                      |
| 10 | Create a simple program related to ways to reduce air pollution     | 2.56                        | 2.88                      |
| 11 | Write down ideas and methods that attract your friends to participate in maintaining the environment | 2.35                        | 2.85                      |
| 12 | Create an innovative idea that you can do as a part of society to campaign against climate change | 2.30                        | 2.67                      |

Regarding the HOTS measurement in each indicator, the results imply that the lowest-scoring indicator is related to creating an innovative idea. This is consistent with results presented in Table 2 regarding creating an innovative idea that also becomes the lowest-scoring aspect. Detailed results can be seen in Table 3.

Table 3. Results of HOTS measurement for each indicator

| No | Indicator                                                      | Vocational students (n=216) | University students (n=48) |
|----|----------------------------------------------------------------|-----------------------------|---------------------------|
| 1  | Analyze climate change phenomena                               | 2.84                        | 3.03                      |
| 2  | Analyze the impacts of climate change                          | 2.57                        | 3.21                      |
| 3  | Criticize the use of excess carbon gas                          | 2.50                        | 2.99                      |
| 4  | Provide opinion on climate change campaign                      | 2.51                        | 3.22                      |
| 5  | Write down innovative ideas to reduce air pollution             | 2.62                        | 2.93                      |
| 6  | Create a design of an innovative idea to campaign for environment | 2.32                        | 2.76                      |
|    | Average score                                                  | 25.60                       | 30.23                     |
|    | Category                                                       | Very low                    | Very low                  |

Likewise, the measurement results for the respective thinking level indicate that both vocational and university students creativity level is low. Detailed results are presented in Table 4. The results confirm that the education system currently in implementation is not optimum in increasing creativity.
Regarding the research results that indicate the low HOTS scores, especially in creative thinking levels, a project to create Smart Trash as a learning medium for elementary students can be assigned to vocational and university students. The Smart Trash learning medium can be a practice tool for students to familiarize themselves with activities that require creative-thinking skills. Results related to Smart Trash learning media can be seen in Table 5.

Table 5. Learning media with smart trash

| No | Aspect                  | Description                                                                 |
|----|-------------------------|-----------------------------------------------------------------------------|
| 1  | Technology use          | The Smart Trash development has met the aspect of the use of the latest technology |
| 2  | Ease of use             | Smart Trash developed must be easy to use. The goal is that students can apply it |
| 3  | Effectiveness of use    | The effectiveness of the use of the Smart Trash must be tested first to measure its impacts on elementary school students |
| 4  | Impacts on the environment | The Smart Trash is an effort to reduce waste to maintain the environment |

The result of HOTS in the research is still low. The result is not as expected; thus, it needs an improvement. The HOTS of both vocational and university students needs enhancements; hence, they could be more analytic and creative in solving environmental problems around them. This includes garbage that becomes a substantial problem for some urban areas. The problem is one of the foci in problem-solving [12][13][14]. Waste is one of the causes of environmental pollution that would affect the occurrence of climate change in the future. Therefore, HOTS improvement is unavoidable in the 21st century education.

The low HOTS usually relates to the lack of HOTS-based teaching materials. This is impactful because HOTS must be trained to be improved. Improving HOTS would require hard work from teachers so that students would want to be more active in discussions and learning. Furthermore, HOTS at the vocational students level must be of a higher level since they play an essential role in developing various tools to meet the needs of the community. The HOTS can be trained by developing better teaching materials; hence, a variety of direct and indirect activities can train the skills [15][16][17][18][19].

The students require HOTS to create diverse solutions to climate change problems. Likewise, university students from various departments must possess environmental skills since they must provide answers to various environmental problems in their surroundings. One of the problems is waste problem. The hope is that they could develop a Smart Trash as a solution to the large amount of waste. Smart Trash could also be used as a medium for environmental learning in elementary schools. Environment protective values also still need to be instilled further in elementary school students.

Smart Trash is a solution to environmental education for elementary school. Vocational and university students as agents of change could be assigned the roles of developers of Smart Trash. They can develop it to be used as a medium for environmental education in elementary schools. Therefore, the results of Smart Trash development would bring increased benefits rather than merely being a
technology-based tool. The use of Smart Trash in education is an effort to optimize various development results of technology-based tools making students as a form of industrial revolution 4.0 demand that is based on information technology [20][21][22][23][24][25]. The to-be-developed Smart Trash can be used in various places from schools, around the schools, to around the home of elementary school students. Smart trash will indirectly have an impact on efforts to prevent climate change by reducing waste volume.

The Smart Trash is also an effort to prevent further climate change. As a learning medium, it plays a role in reducing the piles of garbage around school areas and around the residence of elementary school students. Its use as a learning medium creates a change in learning media trends. Moreover, it can be used to reduce various negative impacts on the environment. It is also an implementation form of contextual learning in compliance with environmental aspects directed to prevent climate change.

4. Conclusion
The research found that the HOTS scores of vocational and university students were low. This result showed that students must improve their HOTS to be able to develop smart trash. Learning development is necessary to improve their HOTS. The HOTS will be valuable in handling environmental problems and one of them is by developing Smart Trash as an alternative learning medium in solving climate change problems for students at the elementary school level. The suggestion from the research is to continue the development of the HOTS learning. Another suggestion is to develop various learning media to improve students HOTS.

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References
[1] Burrascano S et al. 2016 Current European policies are unlikely to jointly foster carbon sequestration and protect biodiversity Biological Conservation 201 370–376
[2] Gilmour J P et al. 2019 The state of Western Australia’s coral reefs. Coral Reefs
[3] Jonell M et al. 2016 Eco-labeled seafood: determinants for (blue) green consumption Sustainability 8 1–19
[4] Rezvani Z et al. 2017 Cause I’ll Feel Good! An Investigation into the Effects of Anticipated Emotions and Personal Moral Norms on Consumer Pro-Environmental Behavior Journal of Promotion Management 23 163–183
[5] Amarasinghe S R and Fernando F F H G 2014 Pro-environmental behavior regarding solid waste management in householders of Kalutara urban council area: A case study Journal of Tropical Forestry and Environment 4 80–84
[6] Gündüz A Y et al. 2016 Design of a problem-based online learning environment and evaluation of its effectiveness The Turkish Online Journal of Educational Technology 15 49–57
[7] Yee M H et al., 2015 Disparity of Learning Styles and Higher Order Thinking Skills among Technical Students Procedia - Social and Behavioral Sciences 204 143–152
[8] Garcia L C 2015 Environmental science issues for higher-order thinking skills (hots) development: A case study in the Philippines Biology Education and Research in a Changing Planet 45–54
[9] Rahmayanti H et al. 2020 Environmental attitude for smart city technology: Need assessment to develop smart trash in environmental education International Journal of Advanced Science and Technology 29 8374–8383
[10] Anderson L W et al. 2001 A taxonomy for learning, teaching and assessing: A revision of bloom’s taxonomy of educational objectives Longman
[11] Ichsan I Z et al. 2019 HOTS-AEP: Higher order thinking skills from elementary to master students in environmental learning European Journal of Educational Research 8 935–942
[12] Yusnaeni Y et al. 2017 Creative Thinking of Low Academic Student Undergoing Search Solve Create and Share Learning Integrated with Metacognitive Strategy International Journal of Instruction 10 245–262
[13] Seechaliao T 2017 Instructional strategies to support creativity and innovation in education Journal of Education and Learning 6 201–208
[14] Sigit D V et al. 2020 EECN: Analysis, potency, benefit for students knowledge and attitude to conserve mangroves and coral reefs International Journal of Instruction 13 125–138
[15] Miarsyah M et al. 2019 MEBA: Development android-based ecosystem module for senior high school students Indian Journal of Public Health Research and Development 10 2114–2118
[16] Ross J 2017 Speculative method in digital education research,” Learning, Media and Technology 42 214–229
[17] Komala R et al. 2020 Group investigation model in environmental learning: An effect for students’ higher order thinking skills Universal Journal of Educational Research 8 9–14
[18] Suryanda A et al. 2020 Analogy and critical thinking skills: Implementation learning strategy in biodiversity and environment topic Universal Journal of Educational Research 8 45–50
[19] Sigit D V et al. 2019 Development green consumerism e-book for undergraduate students (gc-ebooks) as learning media in environmental learning Indian Journal of Public Health Research and Development 10 2026–2031
[20] Motallebzadeh K et al. 2018 Relationship between 21st century skills, speaking and writing skills: A structural equation modelling approach International Journal of Instruction 11 265–276
[21] Smith T 2014 Elementary Science Instruction: Examining a Virtual Environment for Evidence of Learning, Engagement, and 21st Century Competencies Education Sciences 4 122–138
[22] Purwanto A et al. 2020 ESBOR during COVID-19: Analysis students attitude for develop 21st century environmental learning Journal of Sustainability Science and Management 15 20–29
[23] Rahmayanti H et al. 2020 DIFMOL: Indonesian students’ Hots and environmental education model during COVID-19 Journal of Sustainability Science and Management 15 10–19
[24] Ichsan I Z and Rahmayanti H 2020 HOTSEP: Revised Anderson’s Taxonomy in environmental learning of COVID-19 European Journal of Educational Research 9 1257–1265
[25] Ichsan I Z et al. 2021 Thinking Level in Education: A Complete Revision of Anderson’s Taxonomy Pedagogika 141 53–78