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HOTSEP: Revised Anderson's Taxonomy in Environmental Learning of COVID-19

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Abstract: Environmental learning in the 21st century requires a high level of thinking ability, especially to solve environmental problems when COVID-19 pandemic. This was to develop a new level of thinking, namely Higher Order Thinking Skills of Environmental Problem (HOTSEP) which is a revision of Anderson's Taxonomy. The purpose of this study was to measure students HOTSEP in the context of environmental problems related to COVID-19. The research method used in this research was descriptive. The sample used 277 university students from several cities in Indonesia. The instrument used HOTSEP which has 3 categories of thinking level start from develop innovation about environment (C6), solve environmental problem (C5), criticize environmental problem (C4). The results showed that students HOTSEP were still in the very low category (33.64). This study concludes that the HOTSEP of students was still low and needs to be improved to the understanding of COVID-19 concept in environmental learning. Suggestion for further research was HOTSEP need to implement in school or university for several environmental learning topics in many subjects/courses start from Natural Science, Social Science, Engineering, and others relevant subject. HOTSEP can be measured not only in school or university, HOTSEP can be implement in community and public.

Keywords: *COVID-19, environmental learning, HOTSEP.*

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Introduction

The Coronavirus Disease 2019 (COVID-19) outbreak that occurred in 2020 globally had a great impact on activities in various countries (Tian et al., 2020; Zhou et al., 2020). Start from economic activities, social, and educational activities (Bakker & Wagner, 2020; Erduran, 2020). Students are required to do learning at home. That's because implementation of the physical distancing policy in several place to prevent transmission of COVID-19. It also happened in Indonesia as one of the countries affected by COVID-19 which affected various sectors of activity, including educational activities at all levels. Many changes occur after the COVID-19 in learning, one of them is environmental learning in school and university. Environmental learning in this case has an important role in providing a variety of knowledge to students and university students in the context of COVID-19 prevention.

The environmental learning will facilitate students in obtaining various knowledge in the context of environmental-based COVID-19 prevention. The knowledge provided in the form of Higher Order Thinking Skills (HOTS). HOTS is the ability of students to analyze, evaluate, and create a problem solution (Anderson et al., 2001; Garcia, 2015; Saido et al., 2018). In the context of environmental learning, this aspect or thinking level of Anderson et al. (2001) can be revised according to the relevant learning context. The reason of Anderson's Taxonomy in cognitive process (thinking level) revised, its because HOTS which is in Anderson's taxonomy was not compatible with environmental learning in 21st century. Several environmental topics are difficult to measure using Anderson's version of HOTS. One of them was about knowledge of COVID-19 in environment (Ichsan et al., 2020). That makes the thinking level or HOTS aspect according to Anderson had opportunity to be revised following the context of environmental learning in this era. Including revised to measure high-level knowledge about the environment and its impact on the transmission of COVID-19.

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Previous research has created a new dimension from HOTS it's called HOTSHOT and new taxonomy of Marzano, but that dimension/thinking level was not yet suitable for 21st-century environmental learning (Beckwith, 2019; Dubas & Toledo, 2016; Marzano, 2001; Marzano & Kendall, 2006). The results of the latest research on HOTS measured using the aspect/thinking level of Anderson's taxonomy on environmental learning, obtained an evaluate (C5) score 2.17, higher than analyze (C4) score 2.03 for all students. The create (C6) aspect showed the highest score 2.36 (Ichsan et al., 2020). Based on Ichsan et al., (2020) research, the results showed that there were differences in scores with the ideal Anderson concept. Based on Anderson et al. (2001) taxonomy concept, evaluate (C5) should be more difficult than analyze (C4), highest level was create (C6) should be the most difficult level of thinking. This research result by Ichsan et al. (2020) showed the thinking level of Anderson's taxonomy needs to be updated or revised according to the context of 21st-century environmental learning. Moreover, the presence of the COVID-19 outbreak makes this revision an urgent to do especially for HOTS aspects. That's because based on various previous studies, aspects of HOTS according to Anderson's Taxonomy showed that HOTS measurements in terms of environmental learning are not following the current situation (Ichsan et al., 2019). Based on this, there is an opportunity for revise an Anderson thinking level, especially in environmental learning to discuss COVID-19. HOTS which is well known in general, this research will change HOTS for more specifically to Higher Order Thinking Skills of Environmental Problem (HOTSEP).

Other research related to HOTS with Anderson's taxonomy has been carried out, starting from the use of HOTS-based learning models (Husamah et al., 2018; Nabilah et al., 2019; Saido et al., 2018; Vidergor, 2018). In addition to research on learning models, there are also various learning media and assessments developed to empower HOTS capabilities (Alias et al., 2013; Garcia, 2015; Gil-Glazer et al., 2019; Istiyono et al., 2020). Based on this description, measurement research on HOTS used a new thinking level which is called HOTSEP, so it becomes a novelty in this study. HOTSEP becomes a novelty and urgent to be developed in environmental learning. Taxonomy by Anderson et al (2001) was the latest version in 18-20 years ago. In this era at 2020, this taxonomy need to be revised according to contextual situation. Revised Anderson's taxonomy was the current research finding and HOTSEP more contextual or relevant in this current issue on environmental learning. Revised thinking level is innovation and novelty in education, especially environmental learning in Indonesia and HOTSEP can be use in the others country. In addition to revising Anderson's taxonomy in the context of environmental learning, it is necessary to implement HOTSEP in school and university.

Methodology

Research goal

The purpose of this study was to measure students HOTSEP in the context of environmental problems related to COVID-19. That is because in 2020, there was a global COVID-19 pandemic. This makes measurement of HOTSEP in the context of COVID-19 important and urgent.

Research design

This research used descriptive method with descriptive analysis techniques and comparison of average scores for all items and indicators. Descriptive analysis techniques can provide a variety of information related to the ability of respondents in detail and more accurately (Bigirwa et al., 2020; Brown et al., 2019; Cronje et al., 2015). Presentation of data in detail will help to measure each detail of the respondent's abilities more clearly. The instruments used in descriptive research should be developed to be more innovative for contextual result according with the problem to be solved (Bilasa & Taspinar, 2020; Bodzin et al., 2020). This method was chosen because the purpose of this study was to describe the HOTSEP data about COVID-19. This technique for measure HOTS in environmental learning adapted from Ichsan et al. (2019). Descriptive method used for provide details information of HOTS in large sample. This study did not use the experimental method because no treatment was given. That is because the urgency of this research to know descriptively the magnitude of HOTSEP related to the topic COVID-19. Descriptive method will be easier to use for measure something with a relatively short time (Abdullah et al., 2017; Hunaepi et al., 2019; Sigit et al., 2020).

Sample and Data collection

The study conducted in March 2020 during COVID-19 pandemic. The research sample of 277 university students from several cities in Indonesia was chosen randomly by simple random sampling. The sample was divided into 111 male and 166 female students in university level. Age level start from 17 until 35 years old. Data collection was carried out online via Google Form. Instrument distributed by social media through whatsapp and other social media. After answered the test questions via the Google form, then the data collected and then analyzed.

Analyzing Data

This research conducting HOTSEP descriptive analysis to measure student knowledge in the context of COVID-19 at environmental learning. Data were analyzed using category of HOTSEP. This result will be categorized in the HOTSEP category refer to Ichsan et al. (2019). These categories are very high, high, moderate, low, and very low which can be seen in Table 1.

Table 1. HOTSEP category in environmental learning

Category	Interval of Students HOTSEP 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	X ≤ 38,72

Source: category and interval score adapted from Ichsan et al. (2019)

Data were analyzed using Statistical Package for the Social Sciences (SPSS) and Microsoft Excel. The technique used is to make an average for each item and also for each indicator. Analyzing data in this way makes it easy to measured the amount of HOTSEP for each indicator. After that normality test, homogeneity test, independent t-test conducted to compare HOTSEP score between male and female students.

Instrument

The instrument used in this study was HOTSEP with 3 thinking levels/aspect (Thinking levels in Anderson's Taxonomy its called cognitive process). The new taxonomy of three higher thinking level were criticize environmental problem (C4), solve environmental problem (C5), develop innovation about environment (C6), which can be seen in Table 2. In this research, the thinking level that revised in the Higher Order Thinking Skills (HOTS) aspect, while for Lower Order Thinking Skills (LOTS) aspects were not revised.

Table 2. Comparison between HOTS and HOTSEP

HOTS	HOTSEP
Create (C6)	Develop innovation about environment (C6)
Evaluate (C5)	Solve environmental problem (C5)
Analyze (C4)	Criticize environmental problem (C4)

Figure 1 more details illustrates the difference between HOTS (previous version taxonomy by Anderson et al, 2001) and HOTSEP (new version taxonomy). It can be seen that the position of analyze (C4) leveled up and changed into a solve environmental problem (C5). That's because when 21st-century environmental learning is not just analyzing, it must also be able to solve environmental problem. Then evaluate (C5) the level turn down and changed to criticize environmental problem (C4). That is because evaluate (C5) aspect becomes less operational for measuring in environmental learning, so it was more operational to measure criticize the environmental problem. The level of thinking in new taxonomy for criticize environmental problem (C4) was lower than solve environmental problem (C5), because criticize the problem was easier than solve the problem. While create (C6) still in the highest level, but changed to develop innovation about environment (C6). This research didn't change the Lower Order Thinking Skills (LOTS), there were no revisions on LOTS (details can be seen in Figure 1).

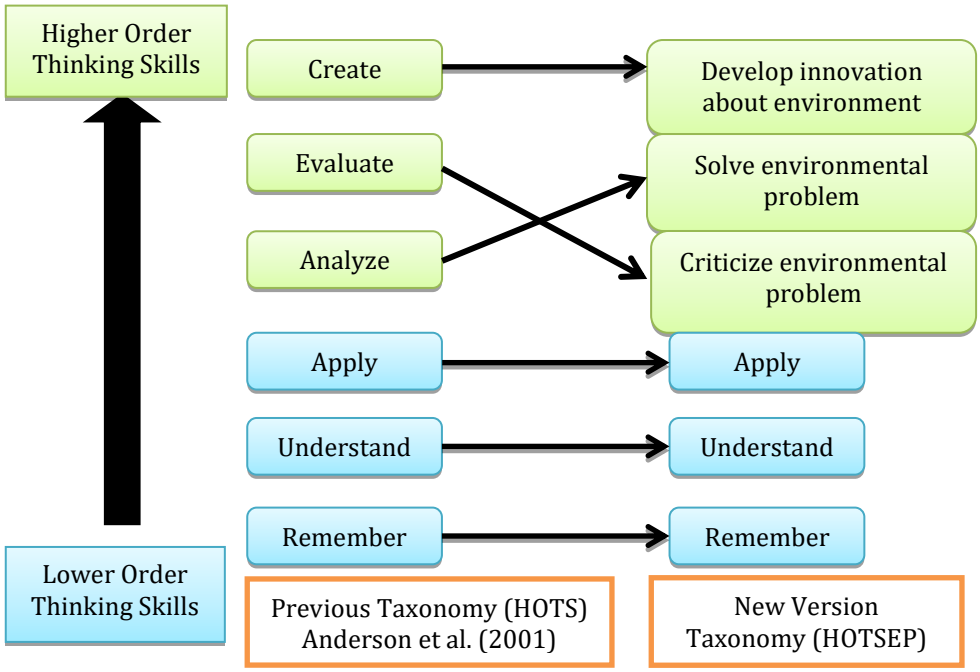

Figure 1. Taxonomy by Anderson et al., 2001 (HOTS) and new version taxonomy (HOTSEP)

HOTSEP descriptive analysis conducted to measure student knowledge in the context of COVID-19 at environmental learning. In this study 12 instrument items and 6 indicators were developed based on the HOTSEP thinking level. The instrument used an interval score from 0 to 10 for each item measured, more details can be seen in Table 3.

Table 3. Indicators of HOTSEP

No	Aspect (Thinking Level)	Indicator	Item
1	Criticize environmental problem (C4)	Criticizing the behavior of people who still littering and not protecting the environment	1,2
2	Criticize environmental problem (C4)	Criticizing the role of the community in protecting the environment during COVID-19	3,4
3	Solve environmental problem (C5)	Solving the problem of low level waste management	5,6
4	Solve environmental problem (C5)	Providing problem solutions of environmental pollution to prevent COVID-19	7,8
5	Develop innovation about environment (C6)	Developing an innovative project to solve problem of flooding caused by the accumulation of garbage	9,10
6	Develop innovation about environment (C6)	Developing a simple program innovation with an online system to encourage community to protect the environment from COVID-19	11,12

Validity and Reliability

The instrument was tested for validity using Pearson product-moment and reliability using a split half method (Spearman-Brown). In this research, the HOTSEP instrument tested for validity and reliability using Statistical Package for the Social Sciences (SPSS). The reliability categories are as follows in Table 4.

Table 4. HOTSEP Reliability categories

Value of Reliability	Category
$0,80 \leq r_{11}$	High reliability of instrument
$0,4 \leq {}_{r11} < 0,80$	Medium reliability of instrument
$r_{11} < 0,4$	Low reliability of instrument

Source: adapted from Ratumanan & Laurens (2006)

The instrument validity test results showed that all items are valid. This showed that the HOTSEP instrument can be used to measure student understanding of environmental learning. Meanwhile, the reliability showed that instrument also reliable to be used with a reliability coefficient of 0.88 which is have a high-reliability category. More complete validity test results can be seen in Table 5.

Table 5. Test results for HOTS instrument validity

Item	r-value	r-table	Category
Item 1	0.75	0.24	Valid
Item 2	0.77	0.24	Valid
Item 3	0.78	0.24	Valid
Item 4	0.73	0.24	Valid
Item 5	0.75	0.24	Valid
Item 6	0.72	0.24	Valid
Item 7	0.74	0.24	Valid
Item 8	0.68	0.24	Valid
Item 9	0.62	0.24	Valid
Item 10	0.75	0.24	Valid
Item 11	0.78	0.24	Valid
Item 12	0.81	0.24	Valid

Results

The results showed that the HOTSEP category of students was still in the very low category. This indicates that environmental learning about COVID-19 needs to be improved. The items with the lowest scores on items 11 and 12 are related to develop innovative programs to prevent COVID-19, which can be more clearly seen in Table 6.

Table 6. Average HOTSEP scores for each item

No	Item	All (n=277)	Male (n=111)	Female (n=166)
1	Criticizing behavior of community who dispose of waste do not according to their type	4.00	4.16	3.89
2	Criticizing and provide advice on community behavior that pollutes river	4.04	4.18	3.95
3	Criticizing community behavior in protecting the environment to prevent COVID-19	3.95	4.04	3.89
4	Criticizing the behavior of the community who littered at the road during COVID-19	3.42	3.48	3.38
5	Giving a problem solution of waste treatment at home	3.21	3.37	3.10
6	Providing ideas to solve river pollution problems due to factory waste	3.30	3.43	3.22
7	Solving the problems from residents living around landfills to prevent COVID-19	2.99	3.09	2.92
8	Solving the problems of COVID-19 prevention efforts through the medical waste that pollutes the environment	3.00	3.09	2.94
9	Developing drainage innovations in urban area	3.51	3.72	3.37
10	Developing an innovative idea so that community can recycle waste	3.24	3.45	3.10
11	Developing an innovative program idea that can be carried out on social media to protect the environment from COVID-19	2.87	3.01	2.77
12	Developing an environment-based innovation to solve the problem of low production of masks when COVID-19	2.84	3.09	2.67
Raw Score		40.37	42.11	39.20
Total Score (Interval 0-100)		33.64	35.09	32.67
Category		Very Low	Very Low	Very Low

The results showed that the indicator with the lowest score was the 6th indicator. This indicator is related to developing an innovative program with an online system to encourage people to protect the environment from COVID-19. This showed that the ability of university students in developing innovations related to COVID-19 is still relatively low (Table 7).

Table 7. Average HOTSEP scores for each indicator

No	Aspect (Thinking Level)	Indicator	All (n=277)	Male (n=111)	Female (n=166)
1	Criticize environmental problem (C4)	Criticizing the behavior of people who still littering and not protecting the environment	4.02	4.17	3.92
2	Criticize environmental problem (C4)	Criticizing the role of the community in protecting the environment during COVID-19	3.68	3.76	3.63
3	Solve environmental problem (C5)	Solving the problem of low level waste management	3.26	3.40	3.16
4	Solve environmental problem (C5)	Providing problem solutions of environmental pollution to prevent COVID-19	2.99	3.09	2.93
5	Develop innovation about environment (C6)	Developing an innovative project to solve problem of flooding caused by the accumulation of garbage	3.37	3.59	3.23
6	Develop innovation about environment (C6)	Developing a simple program innovation with an online system to encourage community to protect the environment from COVID-19	2.85	3.05	2.72

Based on the results of the analysis for each aspect/thinking level showed that the lowest score was in the level of develop innovation about environment (C6) for all students. This is because, at the stage of developing innovation, there are still many students who cannot develop their original ideas, they were still with conventional and non-innovative ideas. The ability to develop innovation is important because it is the highest level. More details can be seen in Table 8. While male students have the lowest score on the C5 aspect because male students are higher in terms of developing innovation rather than solving problems.

Table 8. Average HOTSEP scores for aspects/thinking levels

No	Aspect (Thinking Level)	All (n=277)	Male (n=111)	Female (n=166)
1	Criticize environmental problem (C4)	3.85	3.96	3.78
2	Solve environmental problem (C5)	3.13	3.25	3.05
3	Develop innovation about environment (C6)	3.11	3.32	2.98

The results of the normality test showed that the HOTSEP score were normally distributed. In addition, homogeneity test results showed that HOTSEP scores were homogeneous. Further analysis using the independent t test showed that the value of sig <0.05 and t-value> t-table (t-value higher than t-table) which could be interpreted as a significant difference between the HOTSEP scores between male and female students.

Table 9. HOTSEP t-test independent result between male and female students

Mean difference	t-value	t-table	df	Sig (2.tailed)	Std. Error difference
2.42	2.51	1.64	275	0.01	0.96

This research showed that students, in general, are still weak in terms of developing innovation. That is because the competency to develop innovation is heavier (more difficult) than just create. When developing innovation, students didn't only create product but also must be able to make something innovative and original. This is important, because in the 21st-century learning, creative and innovative ideas from students and university students are strongly emphasized.

Discussion

HOTSEP taxonomy is a more contextual thinking level. That's because HOTSEP has a focus on measuring innovation development to the highest level (C6). While for the levels below, students can provide problem-solving (C5). While the lowest level is related to criticizing the problem (C4). These three levels of thinking are a level of thinking that is more relevant in 21st-century learning. That is because, in the 21st-century, the environment is not only for analysis but students must be critical of the situation and must be able to provide problem-solving for develop an innovation (Dwyer et al., 2014; Ito & Kawazoe, 2015; Puran et al., 2017; Rahmayanti et al., 2020). This change in thinking level be more contextual in measuring various environmental problems in 21st century.

In the context of environmental problems related to COVID-19, this change in thinking level becomes important. That is because this change makes the measurement of student knowledge more accurate. Following the situation during the COVID-19 period that is happening, currently, to solve environmental problems related to COVID-19 it is necessary to also do various innovations in terms of protecting the environment. The innovation can be in the form of an innovative program created original by students. The development of this program requires creativity and the ability to provide innovative original ideas following the 21st century (Deschryver, 2017; Rahmayanti et al., 2020; Ramadhan et al., 2019; Sener et al., 2015). It is a continuation of students' abilities in terms of criticizing problems and solving problems. Students are not only asked to be critical and solve problems but are also asked to have an innovative program to solve various problems, in this case, the COVID-19 problem.

Students who have a high HOTSEP score will be able to solve problem about COVID-19 prevention. Students are expected to be able to innovate so that people want to comply with various policies including the use of masks, washing hands with soap, and physical distancing. Innovative students will be able to think of creating a program that will be able to invite the community to jointly protect the environment to prevent the transmission of COVID-19. This joint effort becomes important because to solve various problems, requires an active effort simultaneously and not just individuals (Derevenskaia, 2014; Ito & Kawazoe, 2015; Sigit et al., 2020; Tsai et al., 2015; Uzun, 2012).

This HOTSEP measurement is the basis for making a description of students' thinking abilities in terms of solving environmental problems. Unlike HOTS which only focuses on common or general problems. HOTSEP prioritizes problems that are more focused on the environmental problem, so that measurements will be more accurate in environmental context. HOTSEP will be an innovation of environmental education in 21st century. HOTSEP can be measured in others subject/course beside environmental education. HOTSEP can be measure in school or university for subject/course Natural Science (Biology, Physics, Chemistry), Social Science (Geography, Economy, Sociology, etc.), Engineering and others relevant subject. That is because HOTSEP more contextual on developing innovation according 21st century learning. Innovation of learning need to improve for better quality of learning (Chanlin et al., 2016; Ito & Kawazoe, 2015; Lee, 2016; Lindfors & Hilmola, 2016; Seechaliao, 2017).

HOTSEP result showed that students' thinking ability still needs to be improved. Although the results of previous studies using the HOTS instrument showed a very low category (Ichsan et al., 2019). Measurement by HOTSEP is more contextual and more relevant to current environmental problems. The student's thought process must also be constantly updated following the progress of developing information technology. A few years ago, students were still

limited with access to information. While in recent years, access to information has become so easy to obtain. Students can find various information about anything on the internet (Reyna et al., 2018; So et al., 2019). The speed of this information is one of the causes need of changes in thinking level at HOTSEP.

Regarding the COVID-19 outbreak, an instrument of measurement needs to be adjusted. HOTSEP is more suitable for measuring students' thinking abilities in terms of the environment. This low category result also showed that HOTSEP needs to be improved with various learning innovations about COVID-19 in the context of environmental learning. That is because innovations such as learning media, learning strategies, learning model, teaching materials, and also student worksheets can support the students HOTSEP for all environmental topic. Innovations like this also need to be done to support 21st-century learning (Hockings et al., 2018; Kivunja, 2015; Reyna et al., 2019; Saputri et al., 2019).

Conclusion

HOTSEP score of students in the context of solving problems related to COVID-19 was still in the very low category. This showed that students do not fully understand the various thinking skills related to the COVID-19 topic in environment. The lowest HOTSEP score related to the develop innovation about environment (C6). Innovation in the 21st century is needed, the ability of students to develop innovation must be improved. Environmental learning tools can be developed to support students HOTSEP in the 21st century.

Suggestions and Limitation

Based on the results of the study, the suggestion for future research is to carry out further implementation of HOTSEP on various/others environmental learning topics. HOTSEP can be implement in many subjects/courses in school and university start from Environmental Education, Natural Science (Biology, Physics, and Chemistry), Social Science (Geography, Economy, Sociology, etc), Engineering, and the others relevant subject. HOTSEP not only for students in school or university, HOTSEP can be measure or implement in community or public. That is because in this study only implemented in the context of COVID-19 prevention in environment. This research only limited to measuring HOTSEP on a very specific topic about COVID-19 in the environmental learning. This also becomes a limitation in this study, because HOTSEP has not yet been implement in other learning topic. This HOTSEP research had a limitation because it was only revised in higher thinking level and only in environmental topics. This research suggests in future to design and complete a new taxonomy for all subjects in school, university and community education.

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