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Higher-Order Thinking Skills of High School and College Students on Flood Mitigation

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ABSTRACT

Background and objective: Numerous flood disaster events encourage mitigation efforts. One of the efforts is education to high school and college students through a project-based learning (PjBL) model during COVID-19. The PjBL innovation can be developed by teachers with a formulation that integrates it with learning media and higher-order thinking skills (HOTS) as the measured parameter.
Methods: The research goal is to analyze high school and college students' HOTS, learning media, and the PjBL model. Learning method employed in the research is descriptive. The HOTS instrument was developed according to Anderson's taxonomy to measure the ability of high school and college students.
Results: The research results indicated that the HOTS score of the high school and college students was very low at 28.29 and 46.01, respectively. The research results suggested an improvement of the HOTS by developing a learning medium to enhance students' HOTS. In addition, the results of the study also showed that the role of teachers and lecturers was very important in facilitating the use of learning media.
Conclusion: Teachers and lecturers in this context must be able to facilitate the formation of loving behavior towards the environment. The learning media will be a content supplement for the primary, secondary, and higher education in learning flood concepts. Based on the results, the conclusion is that high school and college students' HOTS score is in a low category and all aspects of learning media can be integrated with PjBL.

Keywords: higher-order thinking skills (HOTS), learning media, project-based learning

Introduction

Natural disasters continue to occur in several urban areas. One of the disasters is floods. Flood often disturbs the social and economic activities of the communities since it cuts off the road accesses as they are inundated. Ongoing efforts to recover the social and economic activities must be conducted to prevent broader impacts for the communities.

This encourages a more focused development of flood mitigation efforts (Chung and Yen, 2016; Crow and Albright, 2019; Prabawadhani et al., 2016; Sudewi et al., 2015), especially flood disaster during the coronavirus disease 2019 (COVID-19).

Various flood mitigation efforts are available. One of the efforts is through education by classroom learning. The education effort can be done by developing project-based

learning (PjBL). Disaster mitigation-related topics are essential for students and students to learn, especially on the PjBL utilization as a new learning innovation. PjBL as a learning model is an innovation to facilitate students to develop the product (Al-Balushi and Al-Aamri, 2014; Priantari et al., 2020; Seechaliao, 2017; Talmi et al., 2018; Thys et al., 2016). PjBL is an option in learning because it can increase student activities in classroom learning, especially in terms of student creativity in elementary and secondary schools. The utilization of the PjBL in this learning context is useful for being able to produce various products that can be used for the needs of the wider community. For example, the need to conduct education related to flood mitigation. The results of the PjBL-based learning will be more useful for this kind of situation.

The PjBL innovation can be integrated into higher-order thinking skills (HOTS)-based learning media. The learning media content discusses specific parts related to flood mitigation efforts applicable in urban areas. The flood-based learning media must be different from the existing learning media in terms of the integration of the PjBL model. In previous studies, various developments of HOTS-based learning media have been carried out, but most of them have not been effective in improving students' HOTS abilities. Various things that have been developed are related to learning models, learning strategies, and learning media made to improve HOTS abilities (Husamah et al., 2018; Tanujaya, 2016). Moreover, several changes occurred in learning strategies to a digital-based when COVID-19 occurred. The need analysis of flood mitigation topics will have an impact on the development of learning media to become more modern during the COVID-19 (Crawford et al., 2020; Cutri et al., 2020).

Developing the media will require an analysis related to students' current HOTS; hence, the learning media of the PjBL-integrated learning media can be developed consistent with the targets. The importance of learning media by PjBL is confirmed by other previous studies related to the HOTS that strive to develop learning models. Moreover, the PjBL implementation has been done although it has not been integrated. Other findings showed that various learning media have been developed starting from applications used for learning (Hu et al., 2013). In addition, the use of the website as an alternative learning has also been widely developed (Nugraini et al., 2013). These various developments are aimed at measuring students' abilities at various levels of education in elementary and higher education. Based on this description, the role of learning media is crucial in the continuity of learning. Therefore, the research goal was to analyze high school and college students' HOTS, learning media, and PjBL learning.

Research Methods

The research method employed was descriptive with data sampling technique of a survey using Google Form. Samples used included 233 students that consisted of 192 high school students and 41 college students selected using a simple random sampling. The research used an instrument test of an essay where students should provide the answers. The HOTS instrument developed followed the aspects stated in Anderson's taxonomy, namely, analyze, evaluate, and create (Anderson et al., 2001). Next, indicators were developed according to each aspect so that 6 indicators were formed that were used to measure students' HOTS. Indicators developed in the instruments are presented in Table 1.

After completing the measurement of students' HOTS related to the flood prevention efforts, the next step was categorizing the HOTS scores into several categories. The HOTS categorization aimed to simplify the determination of high school and college students' HOTS levels. Therefore, this would facilitate the learning media development to be

Table 1. HOTS indicators

No	Indicator	Item
1	Analyze the impacts of disposing plastic waste and water catchment areas	1, 2
2	Analyze factors causing floods	3, 4
3	Criticize people's littering behavior	5, 6
4	Evaluate the effectiveness of making bio-pores/infiltration wells on land areas of residents' homes	7, 8
5	Create environmental preservation programs through socialization to encourage people to prevent flood	9, 10
6	Create programs to minimize flood disaster	11, 12

applied in the next research. The HOTS categories based on Hidayati et al., (2021) are indicated in Table 2. In addition, a comparison test was conducted using a t-test to measure and compare scores between the two groups.

Next, the research also analyzed the advantages of PjBL if it applied to environmental education. The PjBL analysis was conducted by observing the implementation of education at schools and universities. It was carried out so that the developed media can be adapted to the current state of PjBL usage. The use of PjBL in the classroom would be an illustration to determine the form of learning media to be created. The accuracy of the analysis is vital for a follow-up to future research. The results of the media analysis and the PjBL can be used as the basis for developing learning media that are more suitable to the learning conditions in the classroom.

Results and Discussion

The research results indicate that the students' HOTS score was relatively low regarding flood problem-solving. Flood mitigation topics will be an issue if disasters continue to occur in various areas. High school and college students are agents of change that could educate their surrounding people on floods and their risks. Developing various innovations is one of the solutions to cope with the problem. The high school and college student HOTS scores can be seen in Table 3. Based on the description results presented in Table 3, no comparative t-test was conducted because they were not from the same group of levels; therefore, it will not be equivalent to compare it to the t-test.

Based on the average HOTS score of the high school and college students for each indicator, the lowest score was in indicator C6 (create). HOTS aspect that is at the highest level requires special treatment to create an innovative product. The indicators are outlined in Table 4. The analysis results show that each indicator of high school and college students describes the actual situation of the students. The results of the HOTS measurement indicate the need for further development to improve the various indicators that high school and college students must exceed.

In addition to the results of the descriptive analysis, the study results also suggested that there were significant dif-

Table 2. Categories of high school and college student HOTS score

Category	Score
Very high	$X > 81.28$
High	$70.64 < X \leq 81.28$
Medium	$49.36 < X \leq 70.64$
Low	$38.72 < X \leq 49.36$
Very low	$X \leq 38.72$

Table 3. HOTS score for each item of high school and college students

No.	Item	High school student	College Student
1	Analyze water catchment areas	2.94	5.32
2	Analyze plastic waste issue	3.49	5.68
3	Analyze rain intensity factor as the cause of floods	2.53	4.00
4	Analyze other factors that exacerbate flooding	3.71	5.07
5	Criticize flood mitigation programs	2.47	4.68
6	Respond to the role of the millennial in overcoming floods	2.91	4.20
7	Evaluate the low water catchment areas	2.66	4.29
8	Criticize people's behavior that does not support flood mitigation	2.72	4.39
9	Create ideas so that people are interested in protecting nature	2.81	4.15
10	Write down ideas so that people become wiser in utilizing the environment	2.80	4.68
11	Write down an idea to create awareness among the people to maintain the environment	2.57	4.07
12	Create ideas to encourage people to be proactive in flood mitigation	2.34	4.68
	Average score	28.29	46.01
	Category	Very low	Low

Table 4. HOTS score for each indicator of high school and college student

No.	Indicator	High school student	College Student
1	Analyze the impact of disposing plastic waste and water catchment areas	3.22	5.50
2	Analyze factors causing flood disaster	3.12	4.54
3	Criticize the behavior of people whose littering	2.69	4.44
4	Evaluate the effectiveness of making bio-pores/infiltration wells on the land area of people's home	2.69	4.34
5	Create environmental preservation programs through socialization by encouraging people to prevent flood	2.80	4.41
6	Create programs to minimize flood disaster	2.46	4.38

Table 5. Comparative test results using the t-test

t-value	df	Sig-2 tailed	Mean difference	Std. error difference
11.92	231	.000	17.71	1.48

Table 6. Analysis results of the relationship between learning media and the PjBL

No.	Aspect	Integration between Media and the PjBL
1	Digital-based	Can be developed in the form of digital media containing PjBL elements
2	Respondents involved	Students, college students, or the general public who could access the internet
3	Project produced	Papers, pictures, videos, programs, and others related to flood mitigation

ferences between the 2 groups being compared; however, the college students were better. The results in detail can be seen in Table 5.

Regarding the analysis related to the PjBL application, the result suggests that the model was still used separately. It is recommended to use the learning model integrated with learning media implemented in classroom learning. Overall, the analysis results related to the PjBL application with learning media are shown in Table 6.

These findings indicate that high school and college student environmental learning at the school and university levels was not optimal. Various environmental aspects cannot be further accessed or followed up in solving problems. Therefore, environmental learning seems monotonous and discusses non-actual topics. One actual environmental issue to study is related to the recurring floods (Renald et al., 2016; Shalihati et al., 2016). Hence, disaster-related education is a vital study to conduct.

An effort to educate the public on floods includes the problem of flooding that has become an issue that often occurs in various areas, especially in big cities. The flood mitigation-related issues surely need to be discussed and examined more wisely and in-depth. Various flood problems that occur will certainly make it difficult for the community to carry out its activities. One of the ways to develop socialization is by using the flood mitigation-related learning media that will become a more varied teaching material for teachers at the school and university levels during the COVID-19 situation.

The learning media development must have an orientation towards the implementation of technology-based teaching material development. Educational technology is suitable with the current trend of information technology development in the era of industry revolution 4.0 (Ashraf et al., 2012; Bowden, 2019; Buzov, 2014; Reyna et al., 2018). Social media can be a medium to disseminate various concepts on flood mitigation. Moreover, online-based learning will be more practical in overcoming distance learning constraints, especially during COVID-19.

High school and college students could perceive several advantages of distance learning. Many technical problems, however, must be addressed so that learning can run smoothly. Obstacles in learning could include slow-speed internet access, time management during learning, and internet data. These obstacles should not inhibit learning (Back et al., 2015; Mhouti et al., 2018; Nwagwu, 2020). High school and college students are expected to implement strategies to prevent the obstacles. Besides the use in distance learning, environmental education should be developed in implementing project-based learning (PjBL).

The PjBL implementation will create meaningful learning in class. Learning activities conducted by students will provide usable positive results. Additionally, the PjBL-integrated flood mitigation learning will improve high school and college student creativity. The to-be-developed learning media of flood based on the PjBL model will create active learning; thus, it will improve the HOTS of the high school and college students during the COVID-19 situation. PjBL becomes a suitable model to be able to continue to produce products when the pandemic hits Indonesia. The use of PjBL will be effective if it is supported by various learning media that can be contextual with the problems that exist around students' residence. The use of this contextual material in learning media is important in making learning media appropriate to the development of the 21st century (Cukurova and Bennett, 2018; Heinrichs, 2016; Reyna et al., 2018).

Conclusion

Based on the study results, it was found that students' HOTS score is very low for both high school students (28.29) and college students (46.01). Meanwhile, the results of the HOTS scores of high school and college students have some differences in each indicator. The research concludes that the high school and college student HOTS score was still in a low category. Thus, it requires an improvement with learning media. In addition, the results from the PjBL analysis with learning media show that in the digital aspect, the respondents involved and the project produced can be integrated with PJBL activities. One effort that can be done is by developing learning media about flood, especially flood disasters. The developed learning media must be integrated with the PjBL model to strengthen the result achieved. The research suggests a follow-up to these findings to develop the learning media in future research.

References

Al-Balushi, S.M. and S.S. Al-Aamri. 2014. The effect of environmental science projects on students environmental knowledge and science attitudes. International Research in Geographical and Environmental Education 23(3):213-227. https://doi.org/10.1080/10382046.2014.927167

Anderson, L. W., D.R. Krathwohl, W. Airiasian, K.A. Cruikshank, R.E. Mayer, P.R. Pintrich, J. Raths, and M.C. Wittrock. 2001. A taxonomy for learning, teaching and assessing: A revision of bloom's taxonomy of educational objectives. London, UK: Longman.

Ashraf, S.S., M.A. Rauf, and F.H. Abdullah. 2012. A hands-on approach to teaching environmental awareness and pollutant remediation to undergraduate chemistry students. Research in Science and Technological Education 30(2):173-184. https://doi.org/10.1080/02635143.2012.698604

Back, D.A., F. Behringer, T. Harms, J. Plener, K. Sostmann, and H. Peters. 2015. Survey of e-learning implementation and faculty support strategies in a cluster of mid-European medical schools. BMC Medical Education 15(1):1-9. https://doi.org/10.1186/s12909-015-0420-4

Bowden, H.M. 2019. Problem-solving in collaborative game design practices: epistemic stance, affect, and engagement. Learning, Media and Technology 44(2): 124-143. https://doi.org/10.1080/17439884.2018.1563106

Buzov, I. 2014. Social network sites as area for students' pro-environmental activities. Procedia - Social and Behavioral Sciences 152:1233-1236. https://doi.org/10.1016/j.sbspro.2014.09.304

Chung, S.S. and C.J. Yen. 2016. Disaster prevention literacy among achool administrators and teachers: A study on the plan for disaster prevention and campus network deployment and experiment in Taiwan. Journal of Life Sciences 10(2016):203-214. https://doi.org/10.17265/1934-7391/2016.04.006

Crawford, J., K. Butler-Henderson, J. Rudolph, and M. Glowatz, R. Burtin, P.A. Magni, and S. Lam. 2020. COVID-19: 20 countries' higher education intra-period digital pedagogy responses. Journal of Applied Teaching and Learning (JALT) 3(1):1-20. https://doi.org/10.37074/jalt.2020.3.1.7

Crow, D.A. and E.A. Albright. 2019. Intergovernmental relationships after disaster: state and local government learning during flood recovery in Colorado. Journal of Environmental Policy and Planning 21(3):257-274. https://doi.org/10.1080/1523908X.2019.1623660

Cukurova, M., J. Bennett, and L. Abrahams. 2018. Students' knowledge acquisition and ability to apply knowledge

into different science contexts in two different independent learning settings. Research in Science and Technological Education 36(1):17-34. https://doi.org/10.1080/0263514 3.2017.1336709

Cutri, R.M., J. Mena, and E.F. Whiting. 2020. Faculty readiness for online crisis teaching: transitioning to online teaching during the COVID-19 pandemic. European Journal of Teacher Education 43(4):523-541. https://doi.org/10.1080/02619 768.2020.1815702

Heinrichs, C.R. 2016. Exploring the influence of 21st century skills in a dual language program: A case study. International Journal of Teacher Leadership Heinrichs - Exploring the Influence 37(1):37-56. Retrieved from http://files.eric.ed.gov/fulltext/EJ1137667.pdf

Hidayati, S., Irwandani, A.D. Yusandika, C. Anwar, H. Rahmayanti, I.Z. Ichsan, and M.M. Rahman. 2021. Science and environment for education: Measuring HOTSEP of electricity energy topic using Ichsan and Rahmayanti taxonomy. Journal of Physics: Conference Series 1796(1): 012095. https://doi.org/10.1088/1742-6596/1796/1/012095

Hu, J., B. van der Vlist, G. Niezen, W. Willemsen, D. Willems, and L. Feijs. 2013. Designing the internet of things for learning environmentally responsible behaviour. Interactive Learning Environments 21(2):211-226. https://doi.org/10.1080/10494820.2012.705858

Husamah, D. Fatmawati, and D. Setyawan. 2018. OIDDE learning model: improving higher order thinking skills of biology teacher candidates. International Journal of Instruction 11(2):249-264. https://doi.org/10.12973/iji.2 018.11217a

Mhouti, A.E., M. Erradi, and A. Nasseh. 2018. Using cloud computing services in e-learning process: Benefits and challenges. Education and Information Technologies 23(2):893-909. https://doi.org/10.1007/s10639-017-9642-x

Nugraini, S.H., K.A. Choo, H.S. Hin, and T.S. Hoon. 2013. Students' feedback of e-av biology website and the learning impact towards biology. Procedia - Social and Behavioral Sciences 103:860-869. https://doi.org/10.1016/j.sbspro.2 013.10.408

Nwagwu, W.E. 2020. E-learning readiness of universities in Nigeria- what are the opinions of the academic staff of Nigeria's premier university?. Education and Information Technologies 25(2):1343-1370. https://doi.org/10.1007/s 10639-019-10026-0

Prabawadhani, D.R., B. Harsoyo, T.H. Seto, and B.R. Prayoga. 2016. Karakteristik temporal dan spasial curah hujan penyebab banjir di wilayah dki jakarta dan sekitarnya. Jurnal Sains and Teknologi Modifikasi Cuaca 17(1):21-25. https://doi.org/10.29122/jstmc.v17i1.957

Priantari, I., A.N. Prafitasari, D.R. Kusumawardhani, and S. Susanti. 2020. Improving students' critical thinking through STEAM-PjBL learning. Bioeducation Journal 4(2):95-103. https://doi.org/10.24036/bioedu.v4i2.283

Renald, A., P. Tjiptoherijanto, E. Suganda, and R.D. Djakapermana. 2016. Toward resilient and sustainable city adaptation model for flood disaster prone city: Case study of jakarta capital region. Procedia - Social and Behavioral Sciences 227:334-340. https://doi.org/10.1016/j.sbspro.2016.06.079

Reyna, J., J. Hanham, and P. Meier. 2018. The Internet explosion, digital media principles and implications to communicate effectively in the digital space. E-Learning and Digital Media 15(1):36-52. https://doi.org/10.1177/2 042753018754361

Seechaliao, T. 2017. Instructional strategies to support creativity and innovation in education. Journal of Education and Learning 6(4):201-208. https://doi.org/10.5539/jel.v6n4p201

Shalihati, S.F., M.P. Hadi, and M. Widiyastuti. 2016. Sistem perdagangan risiko bencana dalam pengelolaan banjir antar-wilayah. Majalah Geografi Indonesia 24(1):26-35.

Sudewi, R.S.S., A. Sasmito, and R. Kurniawan. 2015. Identifikasi ambang batas curah hujan saat kejadian banjir di jabodetabek: studi kasus banjir jakarta tanggal 09 februari 2015. Jurnal Meteorologi Dan Geofisika 16(3): 209-215. http://www.doi.org/10.31172/jmg.v16i3.315

Talmi, I., O. Hazzan, and R. Katz. 2018. Intrinsic motivation and 21st century skills in an undergraduate engineering project: the formula student project. Higher Education Studies 8(4):46. https://doi.org/10.5539/hes.v8n4p46

Tanujaya, B. 2016. Development of an instrument to measure higher order thinking skills in senior high school mathematics instruction. Journal of Education and Practice 7(21):144-148. https://doi.org/10.21009/JISAE.011.05

Thys, M., L. Verschaffel, W.V. Dooren, and F. Laevers. 2016. Investigating the quality of project-based science and technology learning environments in elementary school: A critical review of instruments. Studies in Science Education 52(1):1-27. https://doi.org/10.1080/0305726 7.2015.1078575