Chemistry Online Learning Encourages the Students Generic Science Skills to Develop Pro-Environmental Behaviors

Familia Novita Simanjuntak[1], Nelius Harefa[2], Sumiyati[3]
{familia.simanjuntak@uki.ac.id}

Chemistry Education Study Program, Faculty of Teacher's Training and Education, Christian University of Indonesia, Cawang-Jakarta[123]

Abstract. Chemistry learning online during the Covid-19 pandemic still has to achieve HOTS. To enhance the achievement, chemistry learning online should be integrated with generic science skills through some simple chemistry practices based on daily life. The generic science skills are further encouraging to develop pro-environmental behaviors (PEBs). This study discusses two indicators of generic science skills, then analyzes the relationship between those two indicators with PEBs. Samples are purposively selected; they are the students of inorganic and general chemistry class. Data is statistically analyzed to determine the relationship between students' generic science skills with pro-environmental behaviors. The results show that there is no relationship between students' generic science skills with PEBs using the logical consistency and causality indicators. However, further research using other indicators is still needed to support the students developing pro-environmental behaviors so they can actively participate in environmental protection through chemistry learning experiences.

Keywords: Education for Sustainable Development; generic science skills; PEBs

1 Introduction

Chemistry learning aims to understand the nature and changes of matter in nature so it can pursue a human to imitate nature in producing natural products. Further, chemistry learning can lead humans to occupy their knowledge to apply various synthetic materials, such as plastics and semiconductors, as well as control natural processes to benefit and increase their benefit for humans, such as pollution prevention, supply of drinking water, and corrosion prevention technology ([22]; [11]). Chemistry learning becomes part of education for sustainable development (ESD) as the students' autonomy encouragement in developing pro-environmental behaviors (PEBs) ([27]; [19]) which lead to the active participation in protecting and preserving the environment ([25]; [28]).

Chemistry learning should be fundamental for students to apply their chemical knowledge in practicing to perform the main intent of analyzing, synthesizing, and transforming the matter for defined practical purposes through the reasoning on six basic questions [30]. The question is: (1) What is this material made of? (The question of Chemical Identity); (2) How do a

ICES 2021, November 17-18, Jakarta, Indonesia

DOI 10.4108/eai.17-11-2021.2318633

material's properties relate to its composition and structure? (the question of Structure-Property Relationship); (3) Why does a material undergo changes? (the question of Causality); (4) How do those changes happen? (the question of Mechanism); (5) How can those changes be controlled? (the question of Control); and (6) What is the impact of chemical actions? (the question of Benefits-Costs-Risks).

Chemistry learning can achieve sustainable chemistry if it provides a set of topics related to the selection of chemicals, reactions, and processes that are sustainable and green at the same time as the preferences of design and innovation to create some resources, including energy, at a rate at which they can be replaced naturally, and the generation of waste cannot be faster than the rate of their remediation [17]. Chemistry learning should be able to attract students' interest so it can develop philosophy [10] and its learning experiences provide history and ethics that encourage their action in PEBs [26].

The scenario of ESD requires environmental and social issues to become a common discussion during chemistry learning [5]. Moreover, for In-depth study, chemistry learning should be embedded into environmental and sustainability education through Didaktik models related to chemistry contents and teaching by designing, analyzing, reflecting, and developing [15] to manifest students' perception of PEBs [1].

Since the Covid-19 pandemic, chemistry learning has met its biggest obstacle that is a wider distance between teachers and students, so the interaction becomes more limited by online learning. Periodically, online learning causes learning loss [3] that threatens to target chemistry learning that encourages students' general science skills, especially when the students do not have enough internet quota and bad signal during the chemistry online learning. Learning loss worsens chemistry anxiety [23] in students characterized by feeling bored, afraid, and insecure during the learning process, anxious [24]. It can be seen in students comprehension when they present their project which is a lack of proper execution [9].

The chemistry online learning then chooses daily-life-based learning to help students find some chemicals, reactions, and processes related to the topic of inorganic chemistry and general chemistry. The daily-life-based learning ([4]; [29]) approach is expected to encourage students' general science skills which leads to PEBs ([7]; [21]). Generic science skills involve direct and indirect observation, symbolic language, logical framework, awareness of scale, logical consistency, causality, mathematical modeling, and concept building ([13]; [18]). Generic science skills are important for chemistry learning to drive students' successful participation in individuals' practices [15] and the ability to rationalize their logical consistency and causality [14]. Generic science skills will improve learning experiences whilst the process engages the students to do direct and indirect observation broadly through their surroundings phenomenon ([8]; [20]).

Environmental knowledge merged in chemistry learning accelerates the students' generic science skills [12], especially in selecting the proper chemicals, reactions, and processes used in chemistry practices or projects related to learning topics, so the students can decide the best attitude to handle the effect and know to control the risk to the environment [6], as well as, able to define a good opportunity of each process they investigate [2]. This study discusses two indicators of generic science skills they are logical consistency and causality. The objective of the research is to analyze the relationship.

2 Research Methods

The research is a quasi-experimental study with a post-test-only design. The topics are essential and non-essential metals in inorganic chemistry for students of chemistry education study program, and basic chemistry for students of biology education study program. Each student does one project as chemistry experimental based on their daily-life activities at home, then they present the analysis of their findings using logical consistency and causality. Each student also fills the questionnaire to describe the PEBs according to their learning experiences.

2.1 Samples

The research uses purposive samples, they are 27 students of chemistry education study program and 40 students of biology education study programs. Each student followed the course for 16 weeks and actively participated during the course.

2.2 Data Analyze

Data is post-test scores for two indicators, logical consistency and causality, and questionnaire scores for PEBs. Post-test scores are collected by scoring rubric from students' presentations related to the analysis of their findings of essential and non-essential metals topics. Questionnaire scores are counted as the total scores for each student. Data analysis uses statistics by SPSS application to determine the correlation between logical consistency and causality indicators with PEBs, after the normality test for generic science skills and PEBs variables.

3 Results and Discussion

Generally, the situation of students during chemistry online learning is similar. Lack of internet quota and poor connection cause students difficulty to follow the learning flow and direction. They cannot properly accept the teacher's overall explanation and directions. However, the teacher continuously motivates students to finish the project with their best practices, so they can do the presentations well, though sound worried and anxious. The online learning flow was executed slowly and fun to make students stay calm and enjoy.

The chemistry online learning achievement is shown in Table 1 to describe the scores descriptively, then data analysis to determine the relationship between generic science skills with PEBs as shown in Table 2.

Table 1. Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Dev	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Err	Statistic	Std. Err
Causality	67	74	88	80,76	4,049	,423	,293	-,939	,578
Logical Consistency	67	75	88	79,87	3,529	,556	,293	-,454	,578
PEBs	67	42	48	44,48	1,491	-,054	,293	-,671	,578

Table 1 shows that overall students attain good scores, both for logical consistency and causality, but they achieve an average score for PEBs. Skewness and kurtosis score, according to Table 1, are smaller than 1,96 at significancy level 0,05.

Table 2. Relationship between causality and logical consistency with PEBs

		Causality	Logical Consistency	PEBs
Causality	Pearson Correlation	1	-,214	,125

	Sig. (2-tailed)		,082	,315
	N	67	67	67
	Pearson Correlation	-,214	1	-,051
Logical Consistency	Sig. (2-tailed)	,082		,682
	N	67	67	67
	Pearson Correlation	,125	-,051	1
PEBs	Sig. (2-tailed)	,315	,682	
	N	67	67	67

Table 2 shows that pearson correlation score between causality and logical consistency with PEBs is smaller than table correlation score for degree of freedom (N-2) and the significancy level is higher than 0,05.

Discussion

Skewness and kurtosis score shown in Table 1 means there is no normality distribution, and data analysis shown in Table 2 states that there is no relationship between generic science skills with PEBs by logical consistency and causality indicators. Still, by the highest obstacle during the chemistry online learning, the students are able to attain good scores logical consistency and causality indicators. The student's achievements are supported by chemistry learning embedded into environmental and sustainability education through designing, analyzing, reflecting, and developing contents and teaching ([5]; [15]) based on daily-life activities ([4]; [29]; [13]; [18]; [15]; [14]) so the students harvest learning experiences whilst doing the direct and indirect observation broadly on their surroundings phenomenon ([8]; [21]).

Unfortunately, the students cannot define the connection between their surroundings phenomenon as the topic for chemistry learning with the environment protection and preservation which are described as PEBs. Most of them are too focused on achieving a good score so they hardly realize that the project they did relate to environmental protection and preservation. This situation inspires teachers to merge environmental knowledge in chemistry learning [12] such as choosing the proper chemicals, reactions, and processes used in students' projects related to learning topics, so the students can decide the best attitude to handle the effect and know to control the risk to the environment [6], as well as, able to define a good opportunity of each process they investigate [2].

The chemistry online learning needs to be planned and prepared dynamically following the students' reactions and expressions. It can drive maximum the students to understand the nature and changes of matter in nature so they are pursued to imitate nature in producing natural products, and occupy their knowledge in controlling natural processes to benefit and increase their benefit, such as pollution prevention ([22]; [11]). Gradually, the chemistry online learning will accelerate the generic science skills as the students' autonomy encouragement in developing PEBs ([27]; [19]) which leads to active participation in protecting and preserving the environment ([25]; [28]).

4 Conclusion

Data analysis states that there is no relationship between generic science skills with PEBs by logical consistency and causality indicators. Somehow, according to the literature review, there is a connection between generic science skills and PEBs to achieve environmental protection and preservation as the chemistry learning outcome as shown in Figure 1.

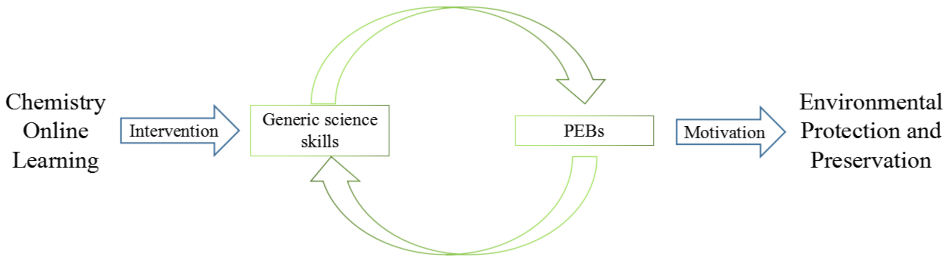

Fig.1. The connection between chemistry online learning with environmental protection and preservation

The discussion states that intervention can be explained by the chemistry online learning is planned and prepared dynamically following the students' reactions and expressions. The motivation aims to control the chemistry anxiety so the students can express the chemistry learning without feeling bored and stay calm to realize the PEBs during the learning process.

Acknowledgements

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. The authors get financial support from Christian University of Indonesia for the research and/or authorship of this article.

References

[1] Abdinejad, M., Talaie, B., Qorbani, H. S., & Dalili, S. Student perceptions using augmented reality and 3d visualization technologies in chemistry education. Vol. 30(1), pp 87-96. Journal of Science Education and Technology (2021).

[2] Akhtar, S., Khan, K. U., Atlas, F., & Irfan, M. Stimulating student's pro-environmental behavior in higher education institutions: an ability–motivation–opportunity perspective. pp 1-22. Environment, Development and Sustainability (2021).

[3] Asiedu, E., Durizzo, K., Günther, I., & Polakova, N. Learning Loss During the Covid-19 Pandemic in Poor Urban Neighborhoods. ETH Zurich. (2021).

[4] Bulte, A. M., Westbroek, H. B., de Jong, O., & Pilot, A. A research approach to designing chemistry education using authentic practices as contexts. Vol. 28(9), pp 1063-1086. International journal of science education (2006).

[5] Burmeister, M., Rauch, F., & Eilks, I. Education for Sustainable Development (ESD) and chemistry education. Vol. 13(2), pp 59-68. Chemistry Education Research and Practice (2012).

[6] Daubenmire, P. L., van Opstal, M. T., Hall, N. J., Wunar, B., & Kowrach, N. Using the chemistry classroom as the starting point for engaging urban high school students and their families in pro-environmental behaviors. Vol. 7(1), pp 60-75. International Journal of Science Education, Part B (2017).

[7] Debus, B., Parastar, H., Harrington, P., & Kirsanov, D. Deep learning in analytical chemistry. Vol. 116459. TrAC Trends in Analytical Chemistry (2021).

[8] Dewi, I. N., Dwi, U. S., Effendi, I., Ramdani, A., & Rohyani, I. S. The Effectiveness of Biology Learning-Local Genius Program of Mount Rinjani Area to Improve the Generic Skills. Vol. 14(1), pp 265-282. International Journal of Instruction (2021).

[9] Engzell, P., Frey, A., & Verhagen, M. D. Learning loss due to school closures during the COVID-19 pandemic. Vol. 118(17). Proceedings of the National Academy of Sciences (2021).

[10] Erduran, S. Philosophy of chemistry: An emerging field with implications for chemistry education. Vol. 10(6), pp 581-593. Science & Education (2001).

[11] Firman, H. Pendidikan Kimia. Ilmu dan Aplikasi Pendidikan Bagian III. Bandung: PT. Imperial Bhakti Utama (2007).

[12] Geiger, S. M., Geiger, M., & Wilhelm, O. Environment-specific vs. general knowledge and their role in pro-environmental behavior. Vol. 10, pp 718. Frontiers in psychology (2019).

[13] Harefa, N., & Suyanti, R. D. Science generic skills of 'chemistry'? prospective teachers: A study on collaborative learning using Exe-media. Vol. 1397, No. 1, p. 012032. Journal of Physics: Conference Series, IOP Publishing (2019).
[14] Hasanah, N., Sahyar, S., & Derlina, D. Ethnophysical Integration In Cooperative Learning Based On Batak Culture To Improve Generic Skills Of Science (Gss) And Student Teamwork. Vol. 10(1), pp 67-71. Jurnal Pendidikan Fisika (2021).
[15] Hayati, A., Juanengsih, N., & Fadlilah, D. R. Laboratory activity-based learning to improve generic science skills on the concept of sensory systems. Vol. 1836, No. 1, p. 012077. Journal of Physics: Conference Series. IOP Publishing (2021).
[16] Herranen, J., Yavuzkaya, M., & Sjöström, J. Embedding Chemistry Education into Environmental and Sustainability Education: Development of a Didaktik Model Based on an Eco-Reflexive Approach. Vol. 13(4), pp 1746. Sustainability (2021).
[17] Horváth, I. T. Introduction: sustainable chemistry. Vol. 118(2), pp 369-371. Chemical reviews (2018).
[18] Khoiri, N., Huda, C., Saefan, J., & Kurniawan, W. Development of Current Stick Teaching Aids to Improve Students' Generic Science Skills. Vol. 6(1), pp 39-44. JIPF (Jurnal Ilmu Pendidikan Fisika) (2021).
[19] Lawrie, G. Chemistry education research and practice in diverse online learning environments: resilience, complexity and opportunity!. Vol. 22(1), pp 7-11. Chemistry Education Research and Practice (2021).
[20] Lewis, R., & Carson, S. Measuring Science Skills Development in New Zealand High School Students After Participation in Citizen Science Using a DEVISE Evaluation Scale. pp 1-10. New Zealand Journal of Educational Studies (2021).
[21] Li, M., Wang, Y., Stone, H. N., & Turki, N. Teaching Introductory Chemistry Online: The Application of Socio-Cognitive Theories to Improve Students' Learning Outcomes. Vol. 11(3), pp 95. Education Sciences (2021).
[22] Mahaffy, P. The future shape of chemistry education. Vol. 5(3), pp 229-245. Chemistry Education Research and Practice (2004).
[23] Oludipe, D., & Awokoy, J. O. Effect of cooperative learning teaching strategy on the reduction of students' anxiety for learning chemistry. Vol. 7(1), pp 30-36. Journal of Turkish science education (2010).
[24] Pangestika, W., & Wiyarsi, A. Chemistry Learning Anxiety Scale: A Scale Development. pp. 241-247. In 6th International Seminar on Science Education (ISSE 2020), Atlantis Press (2021).
[25] Pawlowski, L., Lacy, W. J., Uchrin, C. G., & Dudzinska, M. R. (Eds.). Vol. 51. Chemistry for the Protection of the Environment 2, Springer Science & Business Media. (2012).
[26] Schummer, J. Why chemists need philosophy, history, and ethics. Vol. 2(1), pp 5-6. Substantia (2018).
[27] Simanjuntak, F. N. Pendidikan untuk Pembangunan Berkelanjutan. Vol. 10(2), pp 169-195. Jurnal Dinamika Pendidikan (2017).
[28] Simanjuntak, F. Environmental Chemistry Education for Encouraging the Willingness to Participate in Sustainable Consumption of Food. pp 144-149. In Proceedings of the 3rd International Conference on Social and Political Development - Social Engineering Governance for the People, Technology and Infrastructure in Revolution Industry 4.0 (2019)
[29] Simanjuntak, F. N., & Utama, O. P. A. Pembelajaran Berbasis Kimia Dalam Kehidupan Sehari-Hari Sebagai Penyeimbang Dampak Revolusi Industri 4.0. http://repository.uki.ac.id/id/eprint/3215
[30] Sjöström, J., & Talanquer, V.Eco-reflexive chemical thinking and action. Vol. 13, pp 16-20. Current Opinion in Green and Sustainable Chemistry (2018).