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PROFILE OF UNDERSTANDING OF EDUCATION FOR SUSTAINABLE DEVELOPMENT (ESD) AND LEVEL OF SUSTAINABILITY AWARENESS AMONG PRE-SERVICE CHEMISTRY TEACHERS

FITRIAH KHOIRUNNISA[1,2], ASEP KADAROHMAN[1,*], SJAEFUL ANWAR[1], H. HENDRAWAN[1]

[1]Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 229, Bandung 40154, Indonesia
[2]Universitas Maritim Raja Ali Haji, Jl. Politeknik Senggarang, Tanjungpinang 29111, Indonesia
*Corresponding author: kadar@upi.edu

Abstract

This descriptive study aims to analyse the understanding of Education for Sustainable Development (ESD) and the level of sustainability awareness among pre-service chemistry teachers. The research subjects consisted of sixty-four students who were pre-service teachers within the chemistry education study program at one of the schools in the city of Tanjungpinang. The data collection technique was carried out through a survey with an open-closed form instrument. The survey data were analysed qualitatively. We considered aspects of sustainability emotional awareness with an average score of 55.5% (medium category), aspects of sustainability behavior and attitude awareness with an average score of 68.2% (high category), and aspects of sustainability practice awareness of 51.6% (medium category). The results of the analysis of the understanding of ESD show that as many as 60.5% of pre-service chemistry teachers don't recognize the conception of ESD due to no integration of ESD ideas in chemistry lectures. However, once we explained ESD, the ESD concept within the chemistry course was necessary to be integrated.

Keywords: Education for sustainable development, Pre-service chemistry teacher, Sustainability awareness.

1. Introduction

Education for sustainable development is the latest innovation in education reform, starting from environmental and sustainable education [1-3] . The sustainability of teaching is very abundant and required to prepare somebody to face the most challenges of the twenty-first century. To improve the educational process, chemistry educators have a responsibility to show students concerning the vital role of chemistry in a sustainable future that's packaged in quality learning [4]. The emergence of ESD as an international policy discourse has inspired active discussion from various parties, especially in the field of environmental education (EE) [5]. However, the two terms have different emphases. the emphasis on the "social" aspect is the distinction between the terms ESD and EE, moreover as being the main character of the ESD concept itself [6].

Quality learning can be enriched by research because learning will seem undeveloped without research and research results. On the contrary, learning enriched with research and results will become more innovative. This research-oriented learning is learner-centered learning that aims as a continuing education effort to integrate research into the learning process more than what has been done thus far [7]. In conducting organic chemistry experiments, an experimental activity design is required that focuses on the teaching process for students to "think like chemists", but still pays attention to work safety in a high-hazard environment such as when working in a laboratory [8, 9].

Universities are responsible for providing graduates with good perceptions, attitudes, and existence in line with the idea of ESD [10]. It also wants aid for brand new techniques of their implementation. They may be well-received [11]. Organic Chemistry courses in universities can teach students awareness that good technology is a machine capable of combining many fields of understanding, such as safe experimenting, knowledge of labor protection, and chemical compounds in the laboratory [8]. Practical activities in Organic Chemistry can also be changed to be more environmentally friendly, cheaper, produce less waste, and attract students to tackling environmental problems [12]. The Organic Chemistry course is a potential medium to provide sustainability consciousness that students in their learning process should have, both inside the classroom and in the laboratory.

A field study is needed to investigate in-depth to get a comprehensive image of the understanding of ESD and the level of sustainability awareness of students, especially in chemical science courses. With this information, a recommendation for future improvements will be obtained on how to train the sustainability method for students. This can be following research that recommends the importance of instilling the concept of sustainability in teacher education [13].

2. Literature Review: Waste in Organic Chemistry

Green and sustainable chemistry is an attempt to reduce or, eliminate waste generation in the manufacture and application of chemicals. To manage waste generation in chemical processes, it is important to have metrics to measure them. The two important metrics are measuring the mass efficiency of chemicals [14] and environmental factors [15].

The tendency of organic chemists to optimize the solvent for each step in a multi-step synthesis leads to cross-contamination and difficulties in solvent

recycling [16]. Figure 1 illustrates the manufacture of caprolactam by the conventional process involving the production of cyclohexanone oxime by the reaction of hydroxylamine sulfate with cyclohexanone, followed by sulfuric acid. It is compared to the Sumitomo process involving two catalytic steps that yield two water molecules and have the only co-product (free of salt with environmental factors of less than 0.1) [16].

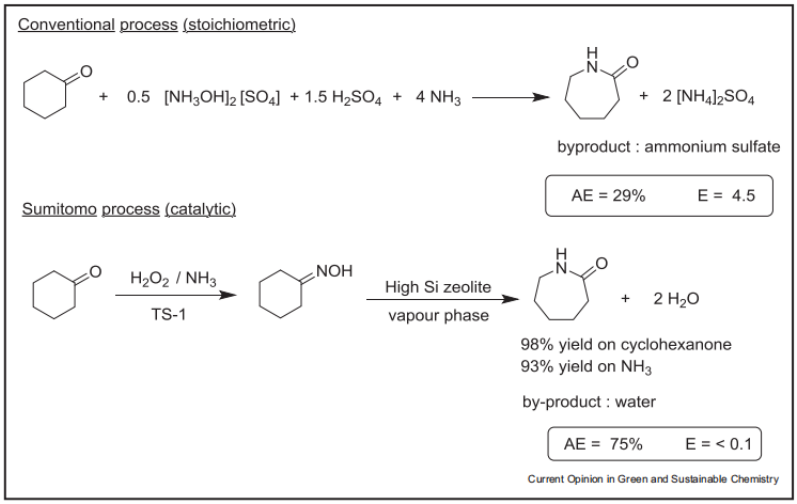

Fig. 1. Sumitomo caprolactam process versus conventional process [12].

3. Research Methods

The subjects of this study were 64 students of prospective chemistry teachers at one of the universities in Tanjungpinang city. The data collection uses an open-ended and close-ended questionnaire with a purposive sampling technique for students who have taken or are currently taking Organic Chemistry courses. Furthermore, the data were analysed using descriptive statistics on two aspects that were measured, namely the understanding of ESD developed by us and the level of sustainability awareness adopted from the research before [17]. The measured aspects are described in Tables 1 and 2. The grouping of level criteria from the sustainability awareness aspect used consists of three criteria, namely high (interval 11-15; $\geq$ 68%), medium (interval 6-10; 34-67%), and low (interval 0-5; $\leq$ 33 %).

Table 1. Categories of aspects of understanding of ESD.

No	ESD Comprehension Category	Item
1	Knowledge of prospective chemistry teachers on Education for Sustainable Development	1, 2, 3
2	Implementation of Education for Sustainable Development in Organic Chemistry Lectures	4, 5, 6
3	Obstacles for prospective chemistry teachers in implementing Education for Sustainable Development in Organic Chemistry lectures	7, 8
4	The urgency of integrating Education for Sustainable Development in Organic Chemistry lectures	9

Table 2. Categories of aspects of sustainable awareness.

No.	Category Sustainability Awareness	Item
1	Sustainability emotional awareness	1, 2, 3, 4
2	Sustainability behavior and attitude awareness	5, 6, 7, 8, 9
3	Sustainability practice awareness	10, 11, 12, 13, 14, 15

Figure 2 describes the procedure for this research, starting from the preparation phase, the data collection phase, the data processing phase, the data analysis phase, and the interpretation and decision-making/conclusion phases.

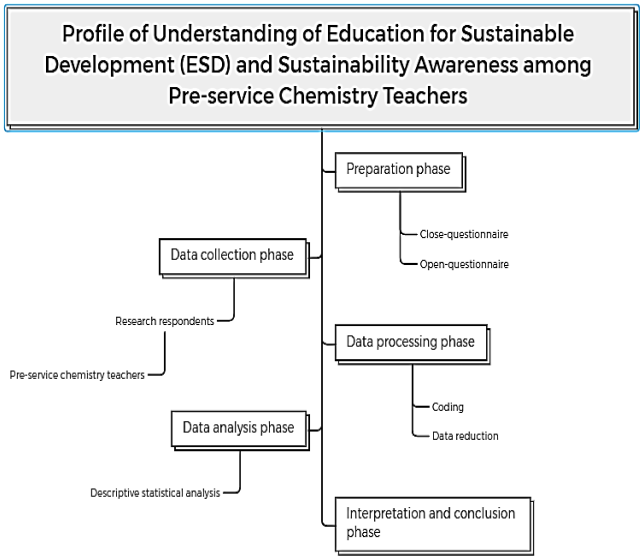

Fig. 2 Research procedure.

4. Results and Discussion

Four aspects are measured to find out how deep the understanding of prospective chemistry teacher students is towards ESD. As many as 60.5% of 64 students stated that they did not know anything about ESD, they were less interested in finding out about ESD because they thought that during lectures, the term ESD was still not conveyed, either in the form of real examples in learning or otherwise. they also said that there were no courses that specifically integrated ESD in the learning process. They expect a socialization program or training or the like related to ESD. It is hoped in the future they can implement it for their students when they become teachers at school. The concept of ESD can foster individuals who contribute to the realization of a more socially, economically, and environmentally sustainable society. The role of education needs to be expanded to include coaching in the community to become accustomed to ethical behavior, integrity, morality, and values. They can take responsible action in creating a better society [18].

Indeed, in its implementation in lectures so far, especially in the Organic Chemistry course at one of the universities in the city of Tanjungpinang, the lecture has not yet integrated matters related to ESD, for example in the Semester Learning

Plan that was developed it still did not explicitly lead to ESD, this is supported by statements from students of 60.5%. When explored further, it turns out that the lack of knowledge and interest of students to find out about ESD is a separate obstacle in implementing ESD, especially in Organic Chemistry lectures. Students have not realized the urgency of ESD in supporting a continuous learning process. The organic chemistry course requires a touch of sustainability in minimizing the chemicals used to reduce the waste used after completing the practicum [19]. The integration of ESD in this course should be a priority. The integration of ESD in Organic Chemistry courses is important and must be realized immediately because sustainable development brings added value to the content and processes in higher education. This is also supported by the research before that the cultivation of ESD needs to be carried out both in all areas of the curriculum and integrated into compulsory or elective courses in study programs [13]. The educational process should be a place to equip students to face various perspectives and contexts to achieve environmental sustainability [20]. Instilling ESD at the university level requires a great commitment from lecturers, students, and staff who must cooperate and have the same perception of the concept of ESD itself [11]. The concept of ESD is quite suitable to be integrated into science learning, and effective science learning help students obtain the information needed for a sustainable world [21]. Based on the results of the analysis of the level of continuous awareness in terms of frequency, the prospective chemistry teacher students are 39.1% (25 students), 26.6% (17 students) are at the medium level, and 34.4% (22 students) is at a low level (see Table 3).

Table 3. Sustainability awareness level of prospective chemistry teacher students.

Criteria	Interval	% Interval	*f*	*f(%)*
High	11-15	68	25	39.1
Medium	6-10	34-67	17	26.6
Low	0-5	33	22	34.4
			64	**100**

Furthermore, the level of sustainability awareness of prospective chemistry teacher students when viewed from each statement item belongs to relatively medium criteria (55.73%). Students tend to have sustainability behavior and attitude awareness at high criteria (68.2%), followed by sustainability emotional awareness at the medium level (55.5%), and sustainability practice awareness at the medium level (51.6%) (see Fig. 2).

Fig. 2. Sustainability awareness level of a pre-service chemistry teacher.

Sustainability behavior and practice awareness is the category that gets the highest criteria among the other two categories. This is shown from one aspect of

student awareness in daily behavior, namely bringing their shopping place when shopping (75%). This awareness also indicates that students have tried to reduce the amount of waste in their environment by collecting recyclable items (62.5%) and have tried to reduce the use of plastic in their lives (59.4%). They have tried to separate organic and non-organic waste according to the space provided (56.3%).

Students realize that separating plastic waste before disposal (59.4%) is something they need to protect the environment. They also feel disappointed when someone throws plastic waste carelessly (53.1%) and gas from burning garbage (polluting the environment) (56.3%). Students have realized the importance of being responsible for the environment (53.1%). More complete data is shown in Table 4.

Table 4. The average value and total percentage are based on sustainability awareness.

No	Statement	Mean	Percentage	Criteria
1	I try to separate plastic waste before throwing it away	38	59.4	Medium
2	I feel disappointed with the gas emitted from burning garbage around my environment	36	56.3	Medium
3	I feel disappointed with the plastic waste that pollutes the rivers around my environment	34	53.1	Medium
4	I realize the importance of being environmentally responsible	34	53.1	Medium
5	I often study environmental issues, especially the dangers of plastic waste through mass media	30	46.9	Medium
6	I try to separate organic and non-organic waste according to the space provided	36	56.3	Medium
7	I try to separate organic and non-organic waste even though there are no special containers provided in the neighborhood	36	56.3	Medium
8	I try to reduce the amount of waste at home by collecting recyclable items	40	62.5	Medium
9	I am working to reduce the use of plastic in my life	38	59.4	Medium
10	I try to bring my shopping place if I want to shop at the store	48	75	High
11	I keep discussing environmental issues with my friends	37	57.8	Medium
12	I compost food scraps into useful items like fertilizer	35	54.7	Medium
13	I do not use plastic bags to wrap somethings	37	57.8	Medium
14	I convey the importance of protecting the environment to my family members	32	50	Medium
15	I am involved in various environmental care activities on campus	24	37.5	Medium
	Mean		**55.73**	**Medium**

Indicator level: $\leq$ 33 low; 34-67 medium; $\geq$ 68 high

Although students have high sustainability behavior and attitude awareness and sustainability emotional awareness in the medium criteria, their sustainability practice awareness is relatively lower than the two categories. Students have not been able to be involved in various events in their institutions related to environmental care (37.5%), but they still tend to implement the awareness they have in themselves. Their ability to discuss environmental issues and convey the importance of protecting the

environment to their colleagues and family members is still lacking, while awareness must be improved [2, 21, 22]. This indicates that the students are still lacking in social activities, whereas in implementing ESD, 3 dimensions must be considered, namely the social, environmental, and economic [21].

5. Conclusion

The results of the analysis of the understanding of ESD show that as many as 60.5% of prospective chemistry teacher students do not know the concept of ESD because there is no integration of ESD concepts in Organic Chemistry lectures. However, after being explained ESD, all students stated that the concept of ESD in the Organic Chemistry course was important to be integrated. Specifically, the sustainability awareness of prospective chemistry teacher students at a university in Tanjungpinang, Indonesia, is classified as "medium". Students already have sustainability behavior and attitude awareness at high criteria (68.2%), followed by sustainability emotional awareness at the medium level (55.5%), and sustainability practice awareness at the medium level (51.6%).

References

1. Suryani, L.; and Hamdu, G. (2021). Education for sustainable development in science national exam questions of elementary school. *ASEAN Journal of Science and Engineering Education*, 1(1), 1-6.
2. Ekamilasari, E.; Pursitasari, I.D. (2021). Students' critical thinking skills and sustainability awareness in science learning for implementation education for sustainable development. *Indonesian Journal of Multidiciplinary Research*, 1(1), 121-124.
3. Theophilus, A.A. (2023). Literature review for civil engineering practice and technology innovation in civil engineering and educational sustainability. *ASEAN Journal of Science and Engineering Education*, 3(2), 183-192.
4. Aubrecht, K.B.; Bourgeois, M.; Brush, E.J., MacKellar, J.; and Wissinger, J.E. (2019). Integrating green chemistry in the curriculum: Building student skills in systems thinking, safety, and sustainability. *Journal of Chemical Education*, 96(12), 2872-2880.
5. Nomura, K. (2009). A perspective on education for sustainable development: Historical development of environmental education in Indonesia. *International Journal of Educational Development*, 29(6), 621-627.
6. McKeown, R.; and Hopkins, C. (2003). EE p ESD: Defusing the worry. *Environmental Education Research*, 9(1), 117-128.
7. Tohir, M.; and Abidin, Z. (2018). Students creative thinking skills in solving two dimensional arithmetic series through research-based learning. *Journal of Physics: Conference Series*, 1008(1), 1-11.
8. Malaguial, P.A.; Maggay, A.K.; Van Sibugan, B.; Salaban, Q.; and Abusama, H. (2021). Classroom experiments using phytochemical analysis of weed (eleusine indica). *Indonesian Journal of Multidiciplinary Research*, 1(2), 325-328.
9. Shaw, N.N.; Sigmann, S.B.; and Richard, L.B. (2021). The research storyboard: Ideas for cultivating safe, engaged, and empowered undergraduate research students. *Journal of Chemical Education*, 98(1), 167-174.

10. Amador, F.; Martinho, A.P.; Bacelar-Nicolau, P.; Caeiro, S.; and Oliveira, C.P. (2015). Education for sustainable development in higher education: Evaluating coherence between theory and praxis. *Assessment and Evaluation in Higher Education,* 40(6), 867–82.
11. Ridwan, I.M.; Kaniawati, I.; Suhandi, A.; Samsudin, A.; and Rizal, R. (2021). Level of sustainability awareness: Where are the students' positions?. *Journal of Physics: Conference Series*, 1806(1), 1-7.
12. MacKellar, J.J.; Constable, D.J.; Kirchhoff, M.M.; Hutchison, J.E.; and Beckman, E. (2020). Toward a green and sustainable chemistry education road map. *Journal of Chemical Education*, 97(8), 2104-2113.
13. Stevenson, R.B.; Lasen, M.; Ferreira, J.A.; and Davis, J. (2017). Approaches to embedding sustainability in teacher education: A synthesis of the literature. *Teaching and Teacher Education*, 63(2017), 405-417.
14. O'Dwyer, A.; and Childs, P.E. (2017). Who says organic chemistry is difficult? exploring perspectives and perceptions. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(7), 3599-3620.
15. Trost, B.M. (1991). The atom economy-a search for synthetic efficiency. *Science*, 254(5037), 1471-1477.
16. Sheldon, R.A.; Bode, M.L.; and Akakios, S.G. (2022). Metrics of green chemistry: Waste minimization. *Current Opinion in Green and Sustainable Chemistry*, 33, 1-6.
17. Noordin, T.A.; and Sulaiman, S. (2010). The status on the level of environmental awareness in the concept of sustainable development amongst secondary school students. *Procedia-Social and Behavioral Sciences*, 2(2), 1276-1280.
18. Kusanagi, K.N. (2020). Education for sustainable development and the implementation of "tokkatsu" in Indonesia. *International Conference on Social Studies and Environmental Issues*, 404, 70-75.
19. Sombria, K.J.F.; Celestial, D.L.; Jalagat, C.G.M.; and Valdez, A.G. (2023). Online learning through google classroom: Effects on students critical thinking skills in chemistry. *ASEAN Journal of Science and Engineering Education*, 3(2), 193-210.
20. Tomas, L.; Mills, R.; Rigano, D.; and Sandhu, M. (2020). Education for sustainable development in the senior earth and environmental science syllabus in Queensland, Australia. *Australian Journal of Environmental Education*, 36(1), 44-62.
21. Uzuntiryaki-Kondakci, E.; and Capa-Aydin, Y. (2013). Predicting critical thinking skills of university students through metacognitive self-regulation skills and chemistry self-efficacy. *Educational Sciences: Theory and Practice*, 13(1), 666-670.
22. Abance, A.C.; Anglacer, S.D.; Soriano, F.J.A.; Umadhay, A.G.C.; Malaco, A.C.; and Besa, A.S. (2021). Respondents' level of education, knowledge, awareness, and acceptability of blue ternate (clitoria ternatea) as alternative medicine. *Indonesian Journal of Multidiciplinary Research*, 1(2), 337-340.